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The Histories

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The Peace of Westphalia and it Affects on International Relations, Diplomacy and Foreign Policy

Steven Patton

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III
The Peace of Westphalia and it Affects on International Relations, Diplomacy and Foreign Policy

By Steven Patton '12

The Peace of Westphalia, signed in 1648, ended the Thirty and Eighty Years Wars and created the framework for modern international relations. The concepts of state sovereignty, mediation between nations, and diplomacy all find their origins in the text of this treaty written more than three hundred and fifty years ago. This peace, which was actually made up of two different peace conferences, was the first attempt at modern international diplomacy and formally solidified the beginnings of religious toleration from a political perspective. It was one of the first attempts at codifying an international set of laws and essentially provided the basis for international communities like the European Union and the United Nations and even laid the groundwork for an early American nation. The Westphalian system still remains the model for international politics around the world and the concept of state sovereignty, solidified by the peace, is still the basis for modern international treaties and conventions.

In order to understand the significance of the Peace of Westphalia, it is necessary to look briefly at the wars which sparked the gathering of the congress. The 30 Years War (1618-1648) was a conflict between feuding Catholic and Protestant estates within the Holy Roman Empire which gradually evolved to become a conflict involving most of Europe.[1] The war was also, and more importantly as far as the lasting effects on international affairs is concerned, about the right of princes in the Empire to sovereign rule. [2] Throughout the conflict, the Catholic Hapsburgs fought Protestant princes of Germany who were supported by France, Sweden, and Denmark.[3] This summation of a thirty-year long conflict obviously is an oversimplification of the complex circumstances which sparked and sustained this war but, for the purposes of explaining the treaty which ensued, is sufficient. The Peace of Westphalia also ended the 80 Years War which raged

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[1] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.
[2] Asch, Ronald G.. *The Thirty Years War: The Holy Roman Empire and Europe 1618-1648.* 1 ed. New York: St. Martain's Press, 1997.
[3] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.

from 1568 until 1648 and was fought over the Netherlands' desire for independence from Spain.[4] After the Twelve Year Truce, a ceasefire agreement between both sides which proved to be short-lived, fighting resumed in 1621 and from then on coincided with the 30 Years War until both wars ended in 1648.[5] Despite this, the prevailing conflict which the peace addressed in greatest detail was the 30 Years War, a war which ravished the Holy Roman Empire, displaced thousands of Europeans, and killed approximately 3-4 million Germans, a significant portion of the population.[6]

The negotiations known as the Congress of Westphalia began in 1642 and lasted another 4 years until the end of the 30 Years War in 1648.[7] Diplomatic representatives from 96 different entities were present at the negotiations which met in two cities within 30 miles of each other-Osnabrück and Münster.[8] The Catholic estates involved in the conflict including Spain, France, the Dutch, the Holy Roman Empire, and a papal mediator met in Münster while the Protestant estates met under the leadership of Sweden and an imperial representative at Osnabrück.[9] During the entire duration of the Congress at Münster and Osnabrück, the war was raging only a "three day's hard ride" from the peace talks.[10] Because a conference on such a large scale had never taken place prior to the 17th century, the "diplomats" who attended the peace talks were "stumbling over conflicting claims of precedent" and were worried that even participating in the negotiations was a threat to their nation's future power.[11] Additionally, while the negotiations commenced in 1642 and the Congress convened on December 4, 1644, some scholars argue that true negotiations did not begin until November of 1645 when Count Trauttmannsdorff, the President of the Imperial Privy Council (of the Holy Roman Empire) arrived in Münster.[12] Finally, by 1648, conditions for nearly every nation involved in the conflict had worsened, the Empire had lost about a third of its population, and leaders began to compromise.[13] Soon after, a compromise was reached and, on October 24, 1648, when the Treaty of Münster was signed, the Peace of Westphalia ended the 30 Years War.[14]

Before an understanding of the peace of Westphalia can be achieved, an analysis of the goals of the treaty must be completed. When the representatives from all involved nations and states met at Münster and Osnabrück, they had certain goals in mind. National representatives

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[4] Britannica, Encyclopedia. "Peace of Westphalia." http://www.britannica.com/EBchecked/topic/641170/Peace-of-Westphalia (accessed April 22, 2009).
[5] Ibid.
[6] McLeod, Toby. ""Thirty Years War" The Oxford Companion to Military History.." (accessed April 22, 2009).
[7] Nathan, James A. *Soldiers, Statecraft, and history: Coercive Diplomacy and International Order.* 1 ed. Westport CT: Praeger Publishers, 2002.
[8] Ibid
[9] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.
[10] Nathan, James A. *Soldiers, Statecraft, and history: Coercive Diplomacy and International Order.* 1 ed. Westport CT: Praeger Publishers, 2002.
[11] Ibid.
[12] Asch, Ronald G.. *The Thirty Years War: The Holy Roman Empire and Europe 1618-1648.* 1 ed. New York: St. Martain's Press, 1997.
[13] Nathan, James A. *Soldiers, Statecraft, and history: Coercive Diplomacy and International Order.* 1 ed. Westport CT: Praeger Publishers, 2002.
[14] Ibid

Count Maximilian Von Trautmansdorff of the Empire, Johan Oxenstienna and Johan Adler Salvius of Sweden, and Comte d'Avaux and Marquis de Sable of France all had specific instructions by the leaders of their own respective nations not to engage in any sort of compromise too quickly.[15] No nation wanted to be seen as weak and none wanted to be held responsible for the more than three decade long destructive conflict. By 1645 there were strong motives for seeking some sort of peace agreement in a war which cost millions of lives including, by some accounts, one third of the entire German population.[16] The goals of the peace conference for each nation can be summed up as follows: the French wanted control of strategic military fortresses including of Metz, Toul, Verdun, Breisach, and Alsace among other areas in addition to four cities on the Rhine known as the "forest cities"; the Empire wanted a united kingdom under the leadership of the Emperor; the princes of the provinces of the Empire wanted sovereignty over their own kingdoms; the Dutch wanted independence from Spain, and Sweden wanted territorial gains of their own.[17] The primary compromises of the represented estates at the congress were written down in the two treaties at Münster and Osnabrück and are summed up by David Maland as follows: the separate states of the Empire were recognized as sovereign; attendance at the established state church was not mandatory; the Peace of Augsburg was affirmed and Calvinism was accepted as a permissible religion; matters of religion were to be settled not by a majority vote but rather by a compromise agreed to by the conflicting parties; the United Provinces were granted independence from Spain and the Empire; Spain was forced to "give away all points to the Dutch", and other land boundaries were shifted.[18] The additional long term effects of the Peace of Westphalia, though likely not immediately foreseen by the writers of the treaties, were far more influential than the short term land and power shifts.

The long term effects of the compromise which were achieved under the Peace of Westphalia were significant and the peace itself was a monumental, modern, and for its time, revolutionary achievement. In his essay on the Peace of Westphalia, Wyndham A. Bewes writes, "no questions that had ever before received a diplomatic settlement had been of such far-reaching importance, or had been settled with the concurrence of so many powers."[19] This notion of an international effort to solve a conflict using diplomatic methods where all sides participated and agreed to compromise, rather than a dominant nation simply dictating policy to a losing nation, was very new in the 17th century.[20] Bewes concludes, "Never [before the congress] had there been such a numerous and brilliant assembly of Ministers and Statesmen of so many different nations and never had so important and complicated political interests been discussed with solemn sufficiency."[21]

The peace dealt with many topics of high importance to the European powers at the time but, from a modern international relations standpoint, three of the issues which were resolved are

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[15] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.
[16] Ibid
[17] Ibid
[18] Maland, David. *Europe at War 1600-1650.* 1 ed. Totowa NJ: Rowman and Littlefield, 1980.
[19] Bewes, Wyndham A.. "Gathered Notes on the Peace of Westphalia." *Transactions of the Grotius Society* 19, no. (1933): 61-73.
[20] Ibid
[21] Ibid.

of particular significance. The first of those issues is the religious freedom which was solidified by the treaties at Münster and Osnabrück. The Peace of Westphalia "confirmed the Peace of Augsburg which had granted Lutherans religious tolerance in the Empire" that had been taken away by Emperor Ferdinand II in his Edict of Restitution of 1629 (the Peace also granted the same tolerance to Calvinists).[22] For religious issues, the peace was "essentially a broadening and a clarification of the Peace at Augsburg" which, both then and in modern society, is of great significance.[23] Before the Peace, states viewed all other foreign nations and policies in terms of good and evil: their own view as good and anything which opposed it as evil.[24] James Nathan sums it up well: "If one side fought with God, it followed that the other had sided with the devil. For the hundred years that preceded the treaties of Westphalia, only truces were permissible."[25] Because of this, the Treaties of Münster and Osnabrück which dealt with rivaling nations were fairly revolutionary. Before any compromises could be made, the dozens of parties present at the congress had to agree on a sort of procedure for the talks. Scholars agree that "it was necessary to reach preliminary agreements on procedure before the actual work of making peace could begin".[26] Luckily, by late in the war, national leaders were quickly growing tired of the conflict and began ordering their representatives at the conferences to make some concessions to put an end to the damages which had been incurred by their states.[27]

While most today would view the diffusion of religious influence in national affairs as a positive aspect of the peace treaty, the Catholic Church and papacy at the time certainly did not. Pope Innocent X, the leader of the Catholic church at the time of the negotiations, denounced the Peace of Westphalia in a papal bull because it undermined his "pan-European political power"[28] Similarly, most Catholics at the time saw the Peace of Augsburg (upon which many of the religious tenets of Westphalia were based) as only a "temporary, emergency measure" which should not become permanent law.[29] What is also significant here is that the writers of the treaties anticipated these objections from both the papacy and the Catholic population throughout Europe. [30] The treaties required any state which signed it to ignore any objection made on the basis of religious supremacy from both Catholic and Protestant leaders.[31] Once the Peace of Westphalia was ratified by each estate's representative, "the role of the Christian community of

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[22] Britannica, Encyclopedia. "Peace of Westphalia." http://www.britannica.com/EBchecked/topic/641170/Peace-of-Westphalia (accessed April 22, 2009).
[23] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.
[24] Nathan, James A. *Soldiers, Statecraft, and history: Coercive Diplomacy and International Order.* 1 ed. Westport CT: Praeger Publishers, 2002.
[25] Ibid
[26] Colegrove, Kenneth. "Diplomatic Procedure Preliminary to the Congress of Westphalia." *The American Journal of International Law* 13, no. 3 (1919): 450-482.
[27] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.
[28] Ibid.
[29] Parker, Geoffrey. *The Thirty Years War.* 2 ed. New York: Routledge & Kegan Paul Inc., 1987.
[30] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.
[31] Ibid

states was replaced by the rule of state consent".[32] This new, revolutionary treaty completely changed the relations between church and state and established a new precedent whereby states would become sovereign entities, immune (generally speaking) from the political pressure of any one church.[33] Conversely, since the Peace's adoption, Catholics, Lutherans, and Calvinists at least could practice their faith without any serious intrusion from the emperor.[34]

The second essential issue with which the Peace of Westphalia dealt was the nature of war and its intended uses. Before 1648, war was the accepted means of instating policy changes when one country found fault with another.[35] It was the "legitimate form of solving conflicts" before the Peace but, after the treaties were agreed upon, "No state was allowed to be destroyed…and compensation was to be awarded to those states that gave up strategically advantageous possessions."[36] Since the mindset of nations thinking in strict terms of "good" and "evil" was beginning to disappear in the 17th century, diplomacy and negotiation could be used as an alternative to war.[37] While this is not to suggest that there was no form of negotiation before the end of the 30 Years War, it seems that official recognition of the diplomats of countries and official offers to compromise could not be utilized in terms of a nation's foreign policy prior to the peace.

The third and possibly most significant and lasting outcome of the Peace of 1648 is the idea of state sovereignty. Before and during the 30 Years War, German provinces were under the rule of the Holy Roman Emperor who controlled the actions of provincial princes.[38] What the Peace of Westphalia effectively established was "territorial superiority in all matters ecclesiastical as well as political" of princes in the Empire.[39] The Peace had given them many rights which were previously held only by the Emperor: "they could ratify peace treaties, they could levy taxes….they could declare war" and possibly most significantly, "war could not be declared by the empire without their consent."[40] This meant that the princes' power was greatly increased while the Holy Roman Emperor saw a drastic reduction in the scope of his.[41] After the peace settlements, power in the Empire had become much more decentralized- a quality which would prove to be very important in diplomatic negotiations in the centuries following the war.

The Peace of Westphalia is seen by many scholars in both history and in the field of international relations to be the basis for much of modern international law and professional diplomacy. [42] Each of the three primary elements of the treaties: wider formal religious freedom,

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[32] Ibid
[33] Parker, Geoffrey. *The Thirty Years War.* 2 ed. New York: Routledge & Kegan Paul Inc., 1987.
[34] Ibid
[35] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.
[36] Nathan, James A. *Soldiers, Statecraft, and history: Coercive Diplomacy and International Order.* 1 ed. Westport CT: Praeger Publishers, 2002.
[37] Ibid.
[38] Ibid
[39] Ibid
[40] Ibid
[41] Ibid
[42] Ibid

the introduction of the diplomatic profession, and the recognition of sovereign states contributed to this long-lasting impact.[43] In the 17th century and throughout the 30 Years War, the idea of supreme central authority of say, the Holy Roman emperor or the papacy, was starting to be questioned though there had been very little effective international diplomacy which tried to alter that reality.[44] Scholars of history, law, and politics were beginning to seek out a more effective system of relations for states which relied less on a supreme central authority and instead diffused more power to each sovereign state.[45] The 17th century historian Hugo Grotius who died shortly before the settlements at Westphalia believed that "kingly states could only achieve complete legitimacy as part of a society of sovereigns to whom they owed certain duties" and "denied that there had to be a supreme sovereign for there to be a law of the society of kingly states or sovereigns."[46] This concept of state sovereignty is a very long lasting one and is still in practice in many areas of foreign policy today including in the U.N., the European Union, and even the United States of America.

These three concepts which were established at Westphalia, however, did not come about overnight; they instead seem to be the work of the evolution of political ideas over the 16th and 17th centuries. Kenneth Colegrove, a former U.S. diplomat and member of the executive council of the American Society for International Law, writes that before the Congress of Westphalia, "International law was in its infancy and the vocabulary of diplomacy had not yet assumed the accuracy and precision which was to characterize it in a later period."[47] He argues that diplomats, if one can call them such during the 17th century, did not even have words like "mediation" in their vocabulary which made the negotiations at the peace congress extremely tedious, perhaps explaining why they took several years.[48] The process which occurred both at the congress and during the years leading up to it was an important piece in the evolution of the diplomatic process and remained in use, unchanged for more than two centuries.

While the concrete achievements which came from the Peace of Westphalia, namely state sovereignty and religious freedom, were obviously significant, the diplomatic process and profession which emerged from the congress was arguably just as important. Auburn University international relations professor James Nathan argues:

> Before the Westphalia settlement, there was no recognizable diplomatic profession. Spies, irregular envoys, and heralds citing scripture or handing out ringing declamations were the usual route that princes chose to alert one another to the start of war. After Westphalia, the diplomatic craft was practiced by a kind of well-born guild, with

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[43] Gross, Leo. "The Peace of Westphalia 1648-1948." *The American Journal of International Law* 42, no. 1 (1948): 20-41.
[44] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.
[45] Ibid
[46] Ibid
[47] Colegrove, Kenneth. "Diplomatic Procedure Preliminary to the Congress of Westphalia." *The American Journal of International Law* 13, no. 3 (1919): 450-482.
[48] Ibid

> members who were adept at melding reason, precedent, and law with quiet allusion to the implication of armed compunction.[49]

Nathan also believes that since the settlement at Westphalia, diplomats and those in combat sought "victory less and the achievement of favorable peace more."[50] This shift in thinking by both diplomats and combatants signaled a way of more modern thinking which paved the way for modern inter-state politics. This was a change from previous medieval political thinking which centered around a system based on obedience to a central hierarchy to a more modern system wherein leaders recognized the sovereignty of each state and had the ability to utilize diplomatic recourses before resorting to war.[51] To further limit the possibility of war, power was dispersed among various states in order to ensure that no one state would have the military might to conquer others without the help of neighboring nations.[52] This is obviously not to say that the Peace prevented all wars but it did set a precedent and provide a platform for discussion between nations in one of the earliest attempts to resolve international conflicts before the outbreak of war. The diplomatic form which emerged from the Congress of Westphalia provided the model upon which international negotiations progressed down through the First World War until the Treaty of Versailles in 1919.[53]

Even after international relations were renegotiated after WWI, scholars argue that the effects of the Peace of Westphalia and the framework which it provided can be seen in many modern international communities including the United Nations, formerly the League of Nations, the European Union, and even to an extent, the United States of America.[54] The charter of the United Nations written in 1945 has some of the very same provisions which were included in the Peace of Westphalia written some 300 years earlier.[55] A scholar of international law at Tufts University, Leo Gross writes that the provisions of the Peace of Westphalia "constitute, in a sense, an early precedent for Articles 10, 12, and 16, or the Covenant of the League of Nations" and that the Charter of the United Nations "would seem to have left essentially unchanged the framework of the state system and of international law resulting from the Peace of Westphalia."[56] Just like the charters of the League of Nations and the United Nations, Westphalia included provisions to discourage war and promote civility between sovereign states.[57] Specifically, the treaty signed at Münster specifically outlawed any immediate recourse to arms. Section CXXIV of the treaty states:

> It shall not be permitted to any State of the Empire to pursue his Right by Force and Arms; but if any difference has happen'd or happens for the future, every one shall try the

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[49] Nathan, James A. *Soldiers, Statecraft, and history: Coercive Diplomacy and International Order.* 1 ed. Westport CT: Praeger Publishers, 2002.
[50] Ibid.
[51] Ibid
[52] Ibid
[53] Ibid
[54] Gross, Leo. "The Peace of Westphalia 1648-1948." *The American Journal of International Law* 42, no. 1 (1948): 20-41.
[55] Ibid
[56] Ibid
[57] Nathan, James A. *Soldiers, Statecraft, and history: Coercive Diplomacy and International Order.* 1 ed. Westport CT: Praeger Publishers, 2002.

> means of ordinary Justice, and the Contravener shall be regarded as an Infringer of the Peace. That which has been determin'd by Sentence of the Judge, shall be put in execution, without distinction of Condition, as the Laws of the Empire enjoin touching the execution of Arrests and Sentences. [58]

This excerpt from the treaty written in the 17th century sounds very similar to the League's charter which bans any recourse to arms of a nation in search of territory expansion.[59]

In addition to laying the foundations of international relations charters like that of the League of Nations, some argue that Westphalia was also an early model for the birth of America and the modern relations of European nations.[60] Phillip Bobbitt, the author of *The Shield of Achilles: War, Peace, and the Course of History* compares Westphalia to Philadelphia which was the birthplace of the American colonies and says that both Westphalia and Philadelphia were "the birthplace of a new constitution for a small society of states.[61] This reference to the American Constitution shows both the longevity of the Peace of Westphalia and its far reaching effects, not just on Europe, but also on North America. Within Europe the peace provided the model for the European Union in which each state or nation keeps its own sovereignty but is united under the larger authority of the Union whose leadership is comprised of its member states. In much the same way, the Westphalian system provided this sort of arrangement for the sovereign principalities of Germany while keeping some form of cohesiveness amongst the Holy Roman Empire.[62]

Scholars would agree that the Peace of Westphalia was, for its time, a revolutionary and monumental achievement; it developed the framework for international diplomacy, a construct which simply did not exist prior to the 17th century. This peace was extremely influential down through the Treaty of Versailles and the Westphalian tradition can still be seen in modern international politics. Compromises reached by the congress in 1648 on the issues of individual state sovereignty, religious tolerance, and diplomatic solutions to international warfare were the precedents of common and international law until the First World War and, arguably, still form the core of foreign policy. The Westphalian tradition can be seen in various modern international forums including the United Nations and is one of history's leading examples of how one conflict can impact the affairs of dozens of independent nations for centuries.

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[58] Toynbee, Arnold. *Major Peace Treaties of Modern History 1648-1967.* 1 ed. 1, Fred L. Israel. New York: Chelsea House Publishers, 1967.
[59] Nathan, James A. *Soldiers, Statecraft, and history: Coercive Diplomacy and International Order.* 1 ed. Westport CT: Praeger Publishers, 2002.
[60] Bobbitt, Philip. *The Shield of Achilles: War, Peace, and the Course of History.* 1 ed. New York: Anchor Books, 2003.
[61] Ibid.
[62] Ibid

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ANNEXURE P-2

THEME 9

THE INDUSTRIAL REVOLUTION

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THE transformation of industry and the economy in Britain between the 1780s and the 1850s is called the 'first industrial revolution'. This had far-reaching effects in Britain. Later, similar changes occurred in European countries and in the USA. These were to have a major impact on the society and economy of those countries and also on the rest of the world.*

This phase of industrial development in Britain is strongly associated with new machinery and technologies. These made it possible to produce goods on a massive scale compared to handicraft and handloom industries. The chapter outlines the changes in the cotton and iron industries. Steam, a new source of power, began to be used on a wide scale in British industries. Its use led to faster forms of transportation, by ships and railways. Many of the inventors and businessmen who brought about these changes were often neither personally wealthy nor educated in basic sciences like physics or chemistry, as will be seen from glances into the backgrounds of some of them.

Industrialisation led to greater prosperity for some, but in the initial stages it was linked with poor living and working conditions of millions of people, including women and children. This sparked off protests, which forced the government to enact laws for regulating conditions of work.

**In the second one, after about 1850, new areas like the chemical and electrical industries expanded. In that period, Britain fell behind, and lost its position as the world's leading industrial power, as it was overtaken by Germany and the USA.*

The term 'Industrial Revolution' was used by European scholars – Georges Michelet in France and Friedrich Engels in Germany. It was used for the first time in English by the philosopher and economist Arnold Toynbee (1852-83), to describe the changes that occurred in British industrial development between 1760 and 1820. These dates coincided with those of the reign of George III, on which Toynbee was giving a series of lectures at Oxford University. His lectures were published in 1884, after his untimely death, as a book called *Lectures on the Industrial Revolution in England: Popular Addresses, Notes and Other Fragments*.

Later historians, T.S. Ashton, Paul Mantoux and Eric Hobsbawm, broadly agreed with Toynbee. There was remarkable economic growth from the 1780s to 1820 in the cotton and iron industries, in coal mining, in the building of roads and canals and in foreign trade. Ashton (1889-1968) celebrated the Industrial Revolution, when England was 'swept by a wave of gadgets'.

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Why Britain?

Britain was the first country to experience modern industrialisation. It had been politically stable since the seventeenth century, with England, Wales and Scotland unified under a monarchy. This meant that the kingdom had common laws, a single currency and a market that was not fragmented by local authorities levying taxes on goods that passed through their area, thus increasing their price. By the end of the seventeenth century, money was widely used as the medium of exchange. By then a large section of the people received their income in the form of wages and salaries rather than in goods. This gave people a wider choice for ways to spend their earnings and expanded the market for the sale of goods.

In the eighteenth century, England had been through a major economic change, later described as the 'agricultural revolution'. This was the process by which bigger landlords had bought up small farms near their own properties and enclosed the village common lands, thus creating very large estates and increasing food production. This forced landless farmers, and those who had lived by grazing animals on the common lands, to search for jobs elsewhere. Most of them went to nearby towns.

Towns, Trade and Finance

From the eighteenth century, many towns in Europe were growing in area and in population. Out of the 19 European cities whose population doubled between 1750 and 1800, 11 were in Britain. The largest of them was London, which served as the hub of the country's markets, with the next largest ones located close to it.

London had also acquired a global significance. By the eighteenth century, the centre of global trade had shifted from the Mediterranean ports of Italy and France to the Atlantic ports of Holland and Britain. Still later, London replaced Amsterdam as the principal source of loans for international trade. London also became the centre of a triangular trade network that drew in England, Africa and the West Indies. The companies trading in America and Asia also had their offices in London. In England the movement of goods between markets was helped by a good network of rivers, and an indented coastline with sheltered bays. Until the spread of railways, transport by waterways was cheaper and faster than by land. As early as 1724, English rivers provided some 1,160 miles of navigable water, and except for mountainous areas, most places in the country were within 15 miles of a river. Since all the navigable sections of English rivers flow into the sea, cargo on river vessels was easily transferred to coastal ships called coasters. By 1800, at least 100,000 sailors worked on the coasters.

'The man of wealth and pride
Takes up a space that many poor supplied;

Space for his lake, his park's extended bounds,
Space for his horses, equipage, and hounds;

The robe that wraps his limbs in silken sloth
Has robbed the neighbouring fields of half their growth.'

– Oliver Goldsmith (1728-74), The Deserted Village.

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ACTIVITY 1

Discuss the developments in Britain and in other parts of the world in the eighteenth century that encouraged British industrialisation.

The centre of the country's financial system was the Bank of England (founded in 1694). By 1784, there were more than a hundred provincial banks in England, and during the next 10 years their numbers trebled. By the 1820s, there were more than 600 banks in the provinces, and over 100 banks in London alone. The financial requirements to establish and maintain big industrial enterprises were met by these banks.

The industrialisation that occurred in Britain from the 1780s to the 1850s is explained partly by the factors described above – many poor people from the villages available to work in towns; banks which could loan money to set up large industries; and a good transport network.

The following pages will describe two new factors: a range of technological changes that increased production levels dramatically and a new transport network created by the construction of railways. In both developments, if the dates are read carefully, one will notice that there is a gap of a few decades between the development and its widespread *application*. One must not assume that a new innovation in technology led to it being used in the industry *immediately*.

Of the 26,000 inventions recorded in the eighteenth century, more than half were listed for the period 1782-1800. These led to many changes. We shall discuss the four major ones: the transformation of the iron industry, the spinning and weaving of cotton, the development of steam 'power' and the coming of the railways.

Coal and Iron

England was fortunate in that coal and iron ore, the staple materials for mechanisation, were plentifully available, as were other minerals – lead, copper and tin – that were used in industry. However, until the eighteenth century, there was a scarcity of *usable iron*. Iron is drawn out from ore as pure liquid metal by a process called smelting. For centuries, charcoal (from burnt timber) was used for the smelting process. This had several problems: charcoal was too fragile to transport across long distances; its impurities produced poor-quality iron; it was in short supply because

Coalbrookdale: blast-furnaces (left and centre) and charcoal-ovens (right); painting by F.Vivares, 1758.

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forests had been destroyed for timber; and it could not generate high temperatures.

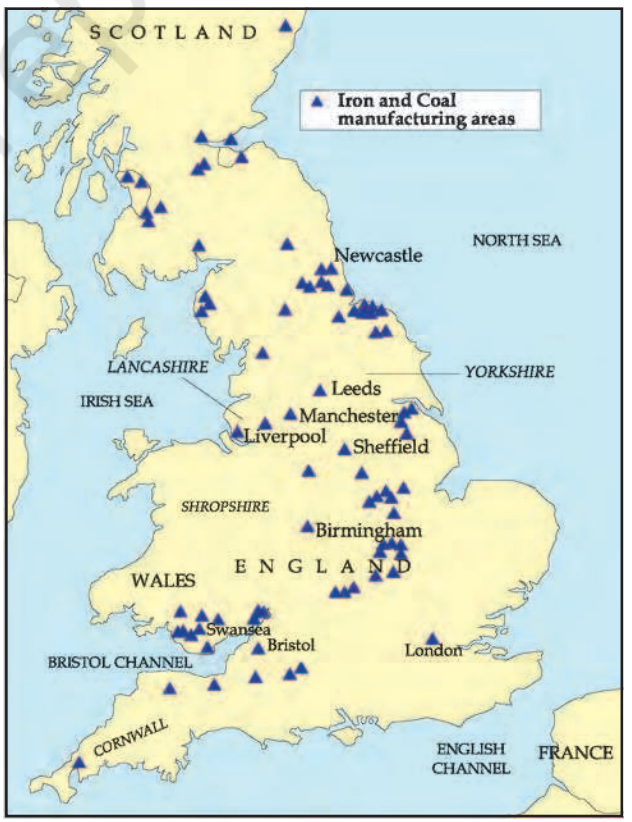
The solution to this problem had been sought for years before it was solved by a family of iron-masters, the Darbys of Shropshire. In the course of half a century, three generations of this family – grandfather, father and son, all called Abraham Darby – brought about a revolution in the metallurgical industry. It began with an invention in 1709 by the first Abraham Darby (1677-1717). This was a blast furnace that would use coke, which could generate high temperatures; coke was derived from coal by removing the sulphur and impurities. This invention meant that furnaces no longer had to depend on charcoal. The melted iron that emerged from these furnaces permitted finer and larger castings than before.

The Cast Iron Bridge near Coalbrookdale, painting by William Williams, 1780.

*This area later grew into the village called Ironbridge.

The process was further refined by more inventions. The second Darby (1711-68) developed wrought-iron (which was less brittle) from pig-iron. Henry Cort (1740-1823) designed the puddling furnace (in which molten iron could be rid of impurities) and the rolling mill, which used steam power to roll purified iron into bars. It now became possible to produce a broader range of iron products. The durability of iron made it a better material than wood for everyday items and for machinery. Unlike wood, which could burn or splinter, the physical and chemical properties of iron could be controlled. In the 1770s, John Wilkinson (1728-1808) made the first iron chairs, vats for breweries and distilleries, and iron pipes of all sizes. In 1779, the third Darby (1750-91) built the first iron bridge in the world, in Coalbrookdale, spanning the river Severn*. Wilkinson used cast iron for the first time to make water pipes (40 miles of it for the water supply of Paris).

MAP 1: Britain: The iron industry



The iron industry then came to be concentrated in specific regions as integrated units of coal mining and iron smelting. Britain was lucky in possessing excellent coking coal and high-grade iron ore in the same basins or even the same seams. These basins were also close to ports; there were five coastal coalfields which could deliver their products almost straight into ships. Since the coalfields were near the coast, shipbuilding increased, as did the shipping trade.

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ACTIVITY 2

Ironbridge Gorge is today a major 'heritage site'. Can you suggest why?

The British iron industry quadrupled its output between 1800 and 1830, and its product was the cheapest in Europe. In 1820, a ton of pig iron needed 8 tons of coal to make it, but by 1850 it could be produced by using only 2 tons. By 1848, Britain was smelting more iron than the rest of the world put together.

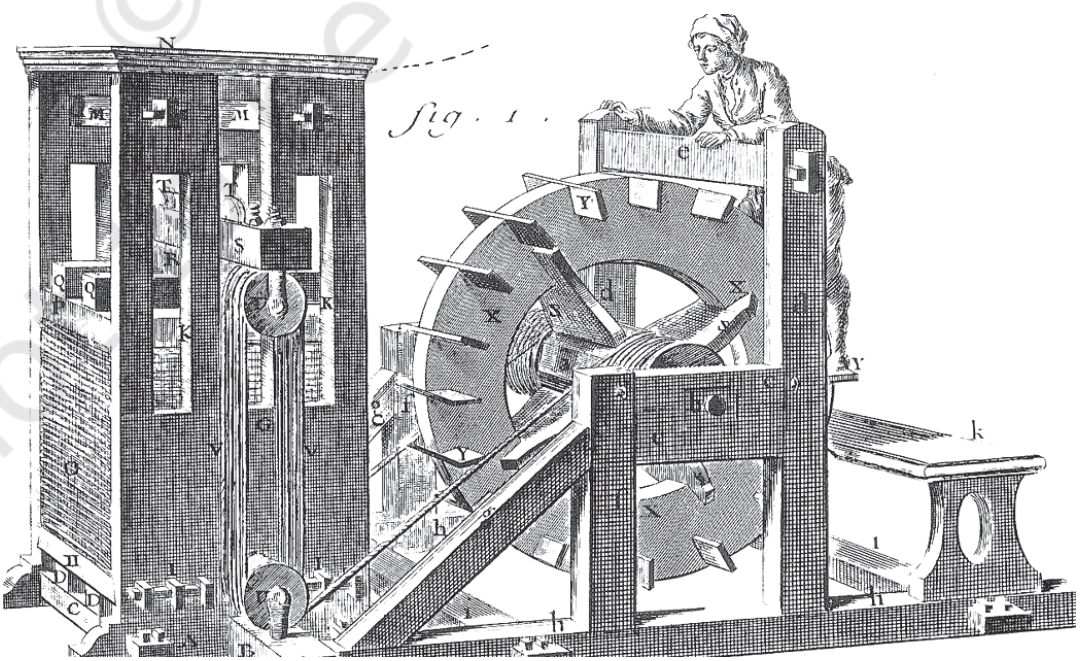
Cotton Spinning and Weaving

The British had always woven cloth out of wool and flax (to make linen). From the seventeenth century, the country had been importing bales of cotton cloth from India at great cost. As the East India Company's political control of parts of India was established, it began to import, along with cloth, raw cotton, which could be spun and woven into cloth in England.

Till the early eighteenth century, spinning had been so slow and laborious that 10 spinners (mostly women, hence the word 'spinster') were required to supply sufficient yarn to keep a single weaver busy. Therefore, while spinners were occupied all day, weavers waited idly to receive yarn. But a series of technological inventions successfully closed the gap between the speed in spinning raw cotton into yarn or thread, and of weaving the yarn into fabric. To make it even more efficient, production gradually shifted from the homes of spinners and weavers to factories.

From the 1780s, the cotton industry symbolised British industrialisation in many ways. This industry had two features which were also seen in other industries.

Raw cotton had to be entirely imported and a large part of the finished cloth was exported. This sustained the process of colonisation,



Manpower (in this picture, woman-power) worked the treadmill that lowered the lid of the cotton press.

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1. The **flying shuttle loom**, *designed by John Kay (1704-64) in 1733 made it possible to weave broader fabrics in less time and consequently called for more yarn than could be supplied at the prevailing pace of spinning.*

2. The **spinning jenny** *was a machine made by James Hargreaves (1720-78) in 1765 on which a single person could spin several threads of yarn simultaneously. This provided weavers with yarn at a faster rate than they could weave into fabric.*

3. The **water frame**, *which Richard Arkwright (1732-92) invented in 1769, produced a much stronger thread than before. This also made it possible to weave pure cotton fabrics rather than fabrics that combined linen and cotton yarn.*

4. The **mule** *was the nickname for a machine invented in 1779 by Samuel Crompton (1753-1827) that allowed the spinning of strong and fine yarn.*

5. The cycle of inventions in the cotton textile industry that sought to maintain a balance between the tasks of spinning and weaving concluded with the invention of the **powerloom** *by Edmund Cartwright (1743-1823) in 1787. This was easy to work, stopped automatically every time a thread broke and could be used to weave any kind of material. From the 1830s, developments in this industry concentrated on increasing the productivity of workers rather than bringing new machines into use.*

MAP 2: Britain: The cotton industry

so that Britain could retain control over the sources of raw cotton as well as the markets.

The industry was heavily dependent on the work of women and children in factories. This exemplified the ugly face of early industrialisation, as will be described below.

Steam Power

The realisation that steam could generate tremendous power was decisive to large-scale industrialisation.

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Water as hydraulic power had been the prime source of energy for centuries, but it had been limited to certain areas, seasons and by the speed of the flow of water. Now it was used differently. Steam power provided pressure at high temperatures that enabled the use of a broad range of machinery. This meant that steam power was the only source of energy that was reliable and inexpensive enough to manufacture machinery itself.

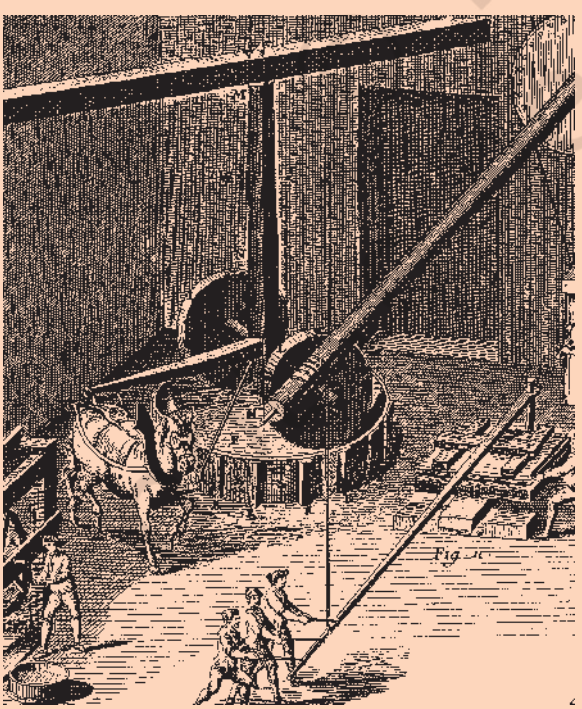
Steam power was first used in mining industries. As the demand for coal and metals expanded, efforts to obtain them from ever-deeper mines intensified. Flooding in mines was a serious problem. Thomas Savery (1650-1715) built a model steam engine called the Miner's Friend in 1698 to drain mines. These engines worked slowly, in shallow depths, and the boiler burst under too much pressure.

Another steam engine was built by Thomas Newcomen (1663-1729) in 1712. This had the major defect of losing energy due to continuous cooling of the condensing cylinder.

The steam engine had been used only in coal mines until James Watt (1736-1819) developed his machine in 1769. Watt's invention converted the steam engine from being a mere pump into a 'prime mover' capable of providing energy to power machines in factories. Backed by the wealthy manufacturer Matthew Boulton (1728-1809), Watt created the Soho Foundry in Birmingham in 1775. From this foundry Watt's steam engines were produced in steadily growing numbers. By the end of the eighteenth century, Watt's steam engine was beginning to replace hydraulic power.

After 1800, steam engine technology was further developed with the use of lighter, stronger metals, the manufacture of more accurate machine tools and the spread of better scientific knowledge. In 1840, British steam engines were generating more than 70 per cent of all European horsepower.

Watt's inventions were not limited to the steam engine. He invented a chemical process for copying documents. He also created a unit of measurement based on comparing mechanical power with that of the previous universal power source, the horse. Watt's measurement unit, horsepower, equated the ability of a horse to lift 33,000 pounds (14,969 kg) one foot (0.3 m) in one minute. Horsepower remains as a universally used index of mechanical energy.



Horses turned the wheels to grind metal. The use of steam reduced the dependence on manpower and horsepower.

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Canals and Railways

Canals were initially built to transport coal to cities. This was because the bulk and weight of coal made its transport by road much slower and more expensive than by barges on canals. The demand for coal, as industrial energy and for heating and lighting homes in cities, grew constantly. The making of the first English canal, the Worsley Canal (1761) by James Brindley (1716-72), had no other purpose than to carry coal from the coal deposits at Worsley (near Manchester) to that city; after the canal was completed the price of coal fell by half.

Canals were usually built by big landowners to increase the value of the mines, quarries or forests on their lands. The confluence of canals created marketing centres in new towns. The city of Birmingham, for example, owed its growth to its position at the heart of a canal system connecting London, the Bristol Channel, and the Mersey and Humber rivers. From 1760 to 1790, twenty-five new canal-building projects were begun. In the period known as the 'canal-mania', from 1788 to 1796, there were another 46 new projects and over the next 60 years more than 4,000 miles of canal were built.

The first steam locomotive, Stephenson's Rocket, appeared in 1814. Railways emerged as a new means of transportation that was available throughout the year, both cheap and fast, to carry passengers and goods. They combined two inventions, the iron track which replaced the wooden track in the 1760s, and haulage along it by steam engine.

The invention of the railways took the entire process of industrialisation to a second stage. In 1801, Richard Trevithick (1771-1833) had devised an engine called the 'Puffing Devil' that pulled trucks around the mine where he worked in Cornwall. In 1814, the railway engineer George Stephenson (1781-1848) constructed a locomotive, called 'The Blutcher', that could pull a weight of 30 tons up a hill at 4 mph. The first railway line connected the cities of Stockton and Darlington in 1825, a distance of 9 miles that was completed in two hours at speeds of up to 24 kph (15 mph), and the next railway line connected Liverpool and Manchester in 1830. Within 20 years, speeds of 30 to 50 miles an hour were usual.

In the 1830s, the use of canals revealed several problems. The congestion of vessels made movement slow on certain stretches of canals, and frost, flood or drought limited the time of their use. The railways now appeared as a convenient alternative. About 6,000 miles of railway was opened in Britain between 1830 and 1850, most of it in two short bursts. During the 'little railway mania' of 1833-37, 1400 miles of line was built, and during the bigger 'mania' of 1844-47, another 9,500 miles of line was sanctioned. They used vast amounts of coal and iron, employed large numbers of workers and boosted activity in the construction and public works industries. Most of England had been connected by railway by 1850.

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Who were the inventors?

It is interesting to find out who the individuals were who brought about these changes. Few of them were trained scientists. Education in basic sciences like physics or chemistry was extremely limited until the late nineteenth century, well after the technological inventions described above. Since these breakthroughs did not require a full knowledge of the laws of physics or chemistry on which they were based, advances could be and were made by brilliant but intuitive thinkers and persistent experimenters. They were helped by the fact that England had certain features which European countries did not. Dozens of scientific journals and published papers of scientific societies appeared in England between 1760 and 1800. There was a widespread thirst for knowledge even in the smaller towns. This was met by the activities of the Society of Arts (founded in 1754), by travelling lecturers, or in 'coffee houses' that multiplied through the eighteenth century.

Most inventions were more the product of determination, interest, curiosity, even luck, than the application of scientific knowledge. Some inventors in the cotton industry, like John Kay and James Hargreaves, were familiar with the skills of weaving and carpentry. Richard Arkwright, however, was a barber and wig-maker, Samuel Crompton was not technically skilled, and Edmund Cartwright studied literature, medicine and agriculture, initially wished to become a clergyman, and knew little of mechanics.

By contrast, in the area of steam engines, Thomas Savery, an army officer, Thomas Newcomen, a blacksmith and locksmith, and James Watt, with a strong mechanical bent, all had some knowledge relevant to their inventions. The road-builder John Metcalf, who personally surveyed surfaces for roads and planned them, was blind. The canal builder James Brindley was almost illiterate, with such poor spelling that he could never spell the word 'navigation', but he had tremendous powers of memory, imagination and concentration.

Changed Lives

In these years, therefore, it was possible for individuals with talent to bring about revolutionary changes. Similarly, there were rich individuals who took risks and invested money in industries in the hope that profits could be made, and that their money would 'multiply'. In most cases this money – capital – did multiply. Wealth, in the form of goods, incomes, services, knowledge and productive efficiency, did increase dramatically. There was, at the same time, a massive negative human cost. This was evident in broken families, new addresses, degraded cities and appalling working conditions in factories. The number of cities in England with a population of over 50,000 grew from two in 1750 to 29 in 1850. This pace of growth was not matched with the provision of adequate housing, sanitation or clean water for the rapidly growing urban population.

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Far left: Coalbrookdale, Carpenters' Row, cottages built by the company for workers in 1783.
Left: The houses of the Darbys; painting by William Westwood, 1835.

Newcomers were forced to live in overcrowded slums in the congested central areas of towns near factories, while the rich inhabitants escaped, by shifting to homes in the suburbs where the air was cleaner and the water safe to drink.

Edward Carpenter eloquently described such cities in about 1881, in his poem 'In a Manufacturing Town'

'As I walked restless and despondent through the gloomy city,
And saw the eager unresting to and fro – as of ghosts in some sulphurous Hades –*
And saw the crowds of tall chimneys going up, and the pall of smoke covering the sun, covering the earth, lying heavy against the very ground –
And saw the huge-refuse heaps writhing with children picking them over,
And the ghastly half-roofless smoke-blackened houses, and the black river flowing below, –
As I saw these, and as I saw again faraway the Capitalist quarter,
With its villa residences and its high-walled gardens and its well-appointed carriages, and its face turned away from the wriggling poverty which made it rich, …
I shuddered.'

**The gates of Hell.*

The Workers

A survey in 1842 revealed that the average lifespan of workers was lower than that of any other social group in cities: it was 15 years in Birmingham, 17 in Manchester, 21 in Derby. More people died, and died at a younger age, in the new industrial cities, than in the villages they had come from. Half the children failed to survive beyond the age of five. The increase in the population of cities was because of immigrants, rather than by an increase in the number of children born to families who already lived there.

Deaths were primarily caused by epidemics of disease that sprang from the pollution of water, like cholera and typhoid, or of the air,

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like tuberculosis. More than 31,000 people died from an outbreak of cholera in 1832. Until late in the nineteenth century, municipal authorities were negligent in attending to these dangerous conditions of life and the medical knowledge to understand and cure these diseases was unknown.

Women, Children and Industrialisation

The Industrial Revolution was a time of important changes in the way that children and women worked. Children of the rural poor had always worked at home or in the farm at jobs that varied during the day or between seasons, under the watchful eye of parents or relatives. Likewise, in villages women were actively involved in farm work; they reared livestock, gathered firewood and spun yarn on spinning wheels in their homes.

Work in the factories, with long, unbroken hours of the same kind of work, under strict discipline and sharp forms of punishment, was completely different. The earnings of women and children were necessary to supplement men's meagre wages. As the use of machinery spread, and fewer workers were needed, industrialists preferred to employ women and children who would be less agitated about their poor working conditions and work for lower wages than men.

They were employed in large numbers in the cotton textile industry in Lancashire and Yorkshire. Women were also the main workers in the silk,

Woman in gilt-button factory, Birmingham. In the 1850s, two-thirds of the workforce in the button trade were women and children. Men received 25 shillings a week, women 7 shillings and children one shilling each, for the same hours of work.

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lace-making and knitting industries, as well as (along with children) in the metal industries of Birmingham. Machinery like the cotton spinning jenny was designed to be used by child workers with their small build and nimble fingers. Children were often employed in textile factories because they were small enough to move between tightly packed machinery. The long hours of work, including cleaning the machines on Sundays, allowed them little fresh air or exercise. Children caught their hair in machines or crushed their hands, while some died when they fell into machines as they dropped off to sleep from exhaustion.

Coal mines were also dangerous places to work in. Roofs caved in or there could be an explosion, and injuries were therefore common. The owners of coal mines used children to reach deep coal faces or those where the approach path was too narrow for adults. Younger children worked as 'trappers' who opened and shut doors as the coal wagons travelled through mines, or carried heavy loads of coal on their backs as 'coal bearers.'

Factory managers considered child labour to be important training for future factory work. The evidence from British factory records reveals that about half of the factory workers had started work when they were less than ten years old and 28 per cent when they were under 14. Women may well have gained increased financial independence and self-esteem from their jobs; but this was more than offset by the humiliating terms of work they endured, the children they lost at birth or in early childhood and the squalid urban slums that industrial work compelled them to live in.

A lane in the poorer quarters of London; engraving by the French artist Dore, 1876.

In his novel Hard Times, Charles Dickens (1812-70), perhaps the most severe contemporary critic of the horrors of industrialisation for the poor, wrote a fictional account of an industrial town he aptly called Coketown. 'It was a town of red brick, or of brick that would have been red if the smoke and ashes had allowed it; but as matters stood it was a town of unnatural red and black like the painted face of a savage. It was a town of machinery and tall chimneys, out of which interminable serpents of smoke trailed themselves for ever and ever, and never got uncoiled. It had a black canal in it, and a river that ran purple with ill-smelling dye, and vast piles of building full of windows where there was a rattling and a trembling all day long, and where the piston of the steam-engine worked monotonously up and down, like the head of an elephant in a stare of melancholy madness.'

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ACTIVITY 3

Discuss the effects of early industrialisation on British towns and villages, and compare these with similar situations in India.

D.H.Lawrence (1885-1930), British essayist and novelist, writing seventy years after Dickens, described the change in a village in the coal-belt, change which he had not experienced, but about which he had heard from older people.

'Eastwood…must have been a tiny village at the beginning of the nineteenth century, a small place of cottages and fragmentary rows of little four-roomed miners' dwellings, the homes of the old colliers…But somewhere about 1820 the company must have sunk the first big shaft…and installed the first machinery of the real industrial colliery…Most of the little rows of dwellings were pulled down, and dull little shops began to rise along the Nottingham Road, while on the down-slope…the company erected what is still known as the New Buildings…little four-room houses looking outward into the grim, blank street, and the back looking into the desert of the square, shut in like a barracks enclosure, very strange.'

Protest Movements

The early decades of industrialisation coincided with the spread of new political ideas pioneered by the French Revolution (1789-94). The movements for 'liberty, equality and fraternity' showed the possibilities of collective mass action, both in creating democratic institutions like the French parliamentary assemblies of the 1790s, and in checking the worst hardships of war by controlling the prices of necessities like bread. In England, political protest against the harsh working conditions in factories kept increasing, and the working population agitated to be given the right to vote. The government reacted by repression and by new laws that denied people the right to protest.

England had been at war with France for a long time – from 1792 to 1815. Trade between England and Europe was disrupted, factories were forced to shut down, unemployment grew and the price of essential items of food, like bread and meat, soared to heights beyond the level of average wages.

Parliament in 1795 passed two Combination Acts which made it illegal to 'incite the people by speech or writing to hatred or contempt of the King, Constitution or Government'; and banned unauthorised public meetings of over 50 persons. Protest, nonetheless, continued against 'Old Corruption'. This term was used for privileges linked to the monarchy and Parliament. Members of Parliament – landowners, manufacturers and professionals – were opposed to giving the working population the right to vote. They supported the Corn Laws, which prevented the import of cheaper food until prices in Britain had risen to a certain level.

As workers flooded towns and factories, they expressed their anger and frustration in numerous forms of protest. There were bread or

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food riots throughout the country from the 1790s onwards. Bread was the staple item in the diet of the poor and its price governed their standard of living. Stocks of bread were seized and sold at a price that was affordable and morally correct rather than at the high prices charged by profit-hungry traders. Such riots were particularly frequent in the worst year of the war,1795, but they continued until the 1840s.

Another cause of hardship was the process known as 'enclosure' – by which, from the 1770s, hundreds of small farms had been merged into the larger ones of powerful landlords. Poor rural families affected by this had sought industrial work. But the introduction of machines in the cotton industry threw thousands of handloom weavers out of work and into poverty, since their labour was too slow to compete with machines. From the 1790s, these weavers began to demand a legal minimum wage, which was refused by Parliament. When they went on strike, they were dispersed by force. In desperation, in Lancashire, cotton weavers destroyed the powerlooms which they believed had destroyed their livelihood. There was also resistance to the introduction of machines in the woollen knitting industry in Nottingham; protests also took place in Leicestershire and Derbyshire.

In Yorkshire, shearing-frames were destroyed by croppers, who had traditionally sheared sheep by hand. In the riots of 1830, farm labourers found their jobs threatened by the new threshing machines that separated the grain from the husk. The rioters smashed these machines. Nine of them were hanged and 450 were sent to Australia as convicts (see Theme 10).

The movement known as Luddism (1811-17), led by the charismatic General Ned Ludd, exemplified another type of protest. Luddism was not merely a backward-looking assault on machines. Its participants demanded a minimum wage, control over the labour of women and children, work for those who had lost their jobs because of the coming of machinery, and the right to form trade unions so that they could legally present these demands.

During the early years of industrialisation, the working population possessed neither the vote nor legal methods to express their anger at the drastic manner in which their lives had been overturned. In August 1819, 80,000 people gathered peacefully at St Peter's Fields in Manchester to claim democratic rights – of political organisation, of public meetings, and of the freedom of the press. They were suppressed brutally in what became known as the Peterloo* Massacre and the rights they demanded were denied by the Six Acts, passed by Parliament the same year. These extended the restrictions on political activity introduced in the two Combination Acts of 1795. But there were some gains. After Peterloo, the need to make the House of Commons more representative was recognised by liberal political groups, and the Combination Acts were repealed in 1824-25.

*This name was made up to rhyme with 'Waterloo'; the French army had been defeated at Waterloo in 1815.

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Reforms through Laws

How attentive was the government to the conditions of work of women and children? Laws were passed in 1819 prohibiting the employment of children under the age of nine in factories and limiting the hours of work of those between the ages of nine and sixteen to 12 hours a day. But this law lacked the powers needed for its enforcement. It was not until 1833, after intense protest by workers throughout the north of England, that an Act was passed that permitted children under nine to be employed only in silk factories, limited the hours of work for older children and provided a number of factory inspectors to ensure that the Act was enforced. Finally, in 1847, after more than 30 years of agitation, the Ten Hours' Bill was passed. This limited the hours of work for women and young people, and secured a 10-hour day for male workers.

These Acts applied to the textile industries but not to the mining industry. The Mines Commission of 1842, set up by the government, revealed that working conditions in mines had actually become worse since the Act of 1833, because more children had been put to work in coal mines. The Mines and Collieries Act of 1842 banned children under ten and women from working underground. Fielder's Factory Act laid down in 1847 that children under eighteen and women should not work more than 10 hours a day. These laws were to be enforced by factory inspectors, but this was difficult to do. The inspectors were poorly paid and easily bribed by factory managers, while parents lied about the real ages of their children, so that they could work and contribute to family incomes.

ACTIVITY 4

Argue the case for and against government regulation of conditions of work in industries.

The Debate on the 'Industrial Revolution'

Until the 1970s, historians used the term 'industrial revolution' for the changes that occurred in Britain from the 1780s to the 1820s. From then, it was challenged, on various grounds.

Industrialisation had actually been too gradual to be considered a 'revolution'. It carried processes that already existed towards new levels. Thus, there was a *relatively* greater concentration of workers in factories, and a *wider* use of money.

Until well into the nineteenth century, large regions of England remained untouched by factories or mines and therefore the term 'industrial revolution' was regarded as inaccurate: England had changed in a *regional* manner, prominently around the cities of London, Manchester, Birmingham or Newcastle, rather than throughout the country.

Could the growth in the cotton or iron industries or in foreign trade from the 1780s to the 1820s be called revolutionary? The impressive growth of cotton textiles, based on new machinery, was in an industry that relied on a non-British raw material, on sales abroad (especially

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India), on non-metallic machinery, and with few links to other branches of industry. Metallic machinery and steam power was rare until much later in the nineteenth century. The rapid growth in British imports and exports from the 1780s occurred because of the resumption of trade with North America that the War of American Independence had interrupted. This growth was recorded as being sharp only because it started from a low point.

Indicators of economic change occurring before and after 1815-20 suggest that sustained industrialisation was to be seen *after* rather than *before* these dates. The decades after 1793 had experienced the disruptive effects of the French Revolutionary and Napoleonic Wars. Industrialisation is associated with a growing investment of the country's wealth in 'capital formation', or building infrastructure and installing new machinery, and with raising the levels of efficient use of these facilities, and with raising productivity. Productive investment, in these senses, grew steadily only after 1820, as did levels of productivity. The cotton, iron and engineering industries had accounted for less than half of the industrial output until the 1840s. Technical progress was not limited to these branches, but was visible in other branches too, like agricultural processing and pottery.

In searching for an answer as to why British growth may have been faster after 1815 than before, historians have pointed to the fact that from the 1760s to 1815, Britain tried to do two things simultaneously – to industrialise, and to fight wars in Europe, North America and India – and it may possibly have failed with one. Britain was at war for 36 out of 60 years from 1760. Capital that was borrowed was used to fight the wars rather than invested. As much as 35 per cent of the cost of the war was met by taxing people's incomes. Workers were transferred out of factories and farms to the army. Food prices rose so sharply that the poor had little money left for buying consumer goods. Napoleon's policies of blockade, and British reactions to them, closed the European continent, the destination for more than half of British exports, to British traders.

The word 'industrial' used with the word 'revolution' is too limited. The transformation extended beyond the economic or industrial sphere and into society and gave prominence to two classes: the bourgeoisie and the new class of proletarian labourers in towns and in the countryside.

In 1851, visitors thronged the Great Exhibition at the specially constructed Crystal Palace in London to view the achievements of British industry. At that time, half the population was living in towns, but of the workers in towns as many were in handicraft units as in factories. From the 1850s, the proportion of people living in urban areas went up dramatically, and most of these were workers in industry – the working class. Only 20 per cent of Britain's workforce now lived in rural areas. This was a far more rapid rate of industrialisation than had been witnessed in other European countries. In his detailed study of British industry, the historian A.E. Musson has suggested that

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The Great Exhibition of 1851 displayed "the Works of Industry of all Nations", particularly the spectacular progress of Britain. It was held in London's Hyde Park, in the Crystal Palace, made of glass panes set in iron columns manufactured in Birmingham.

'There are good grounds for regarding the period 1850-1914 as that in which the Industrial Revolution really occurred, on a massive scale, transforming the whole economy and society much more widely and deeply than the earlier changes had done.'

Exercises

ANSWER IN BRIEF

1. *How did Britain's involvement in wars from 1793 to 1815 affect British industries?*
2. *What were the relative advantages of canal and railway transportation?*
3. *What were the interesting features of the 'inventions' of this period?*
4. *Indicate how the supply of raw materials affected the nature of British industrialisation.*

ANSWER IN A SHORT ESSAY

5. *How were the lives of different classes of British women affected by the Industrial Revolution?*
6. *Compare the effects of the coming of the railways in different countries in the world.*

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Darwin Wallace Galton

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ANNEXURE P-3

THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS

WITH A STUDY OF
THE RELATIONS OF LIVING AND EXTINCT FAUNAS
AS ELUCIDATING THE
PAST CHANGES OF THE EARTH'S SURFACE.

BY

ALFRED RUSSEL WALLACE,

AUTHOR OF "THE MALAY ARCHIPELAGO," ETC.

WITH MAPS AND ILLUSTRATIONS.

IN TWO VOLUMES.—VOLUME I.

London:
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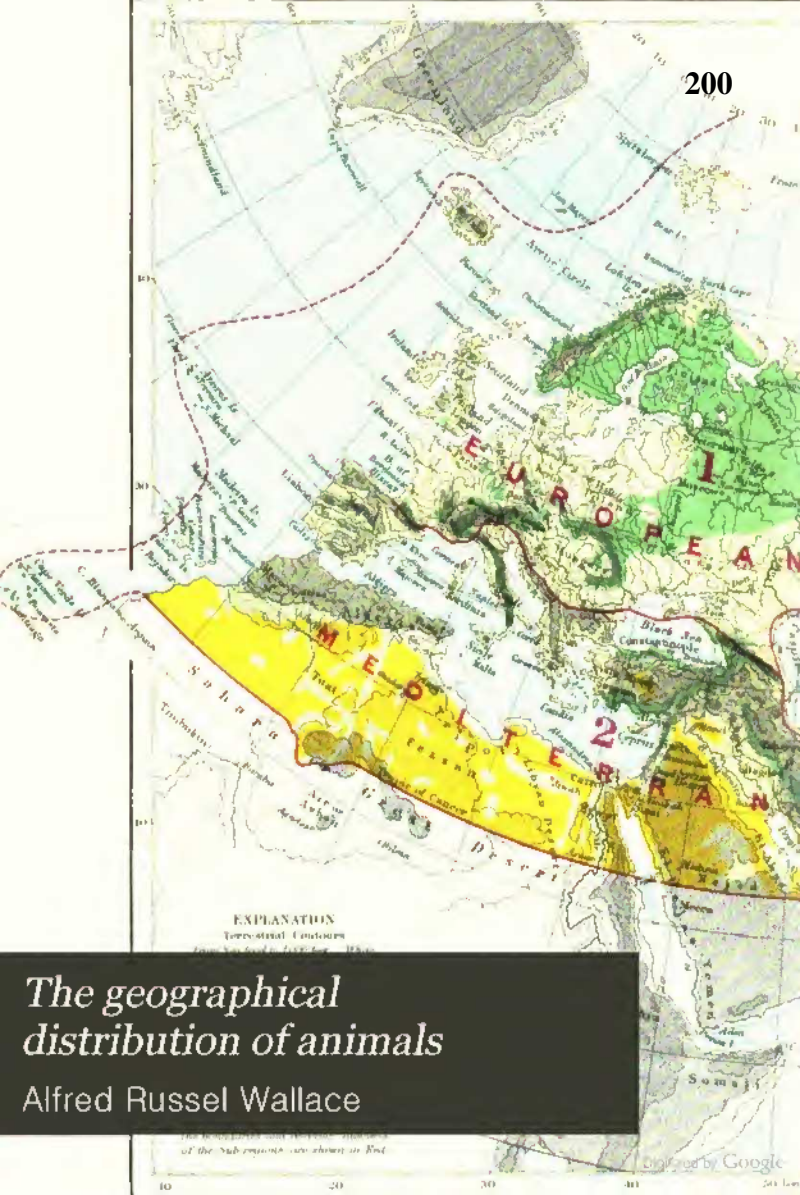

The geographical distribution of animals

Alfred Russel Wallace

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THE GEOGRAPHICAL
DISTRIBUTION OF ANIMALS.

VOL. I.

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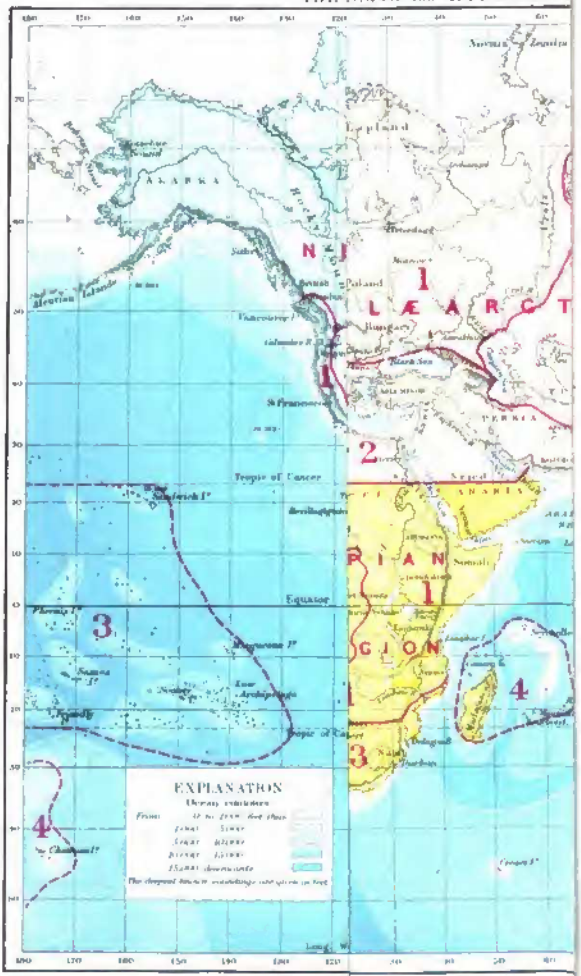

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PREFACE.

THE present work is an attempt to collect and summarize the existing information on the Distribution of Land Animals; and to explain the more remarkable and interesting of the facts, by means of established laws of physical and organic change.

The main idea, which is here worked out in some detail for the whole earth, was stated sixteen years ago in the concluding pages of a paper on the "Zoological Geography of the Malay Archipelago," which appeared in the *Journal of Proceedings of the Linnean Society* for 1860; and again, in a paper read before the Royal Geographical Society in 1863, it was briefly summarized in the following passage:—

"My object has been to show the important bearing of researches into the natural history of every part of the world, upon the study of its past history. An accurate knowledge of any groups of birds or of insects and of their geographical distribution, may enable us to map out the islands and continents of a former epoch,—the amount of difference that exists between the animals of adjacent districts being closely related to preceding geological changes. By the collection of such minute facts, alone, can we hope to fill up a great gap in the

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past history of the earth as revealed by geology, and obtain some indications of the existence of those ancient lands which now lie buried beneath the ocean, and have left us nothing but these living records of their former existence."

The detailed study of several groups of the birds and insects collected by myself in the East, brought prominently before me some of the curious problems of Geographical Distribution; but I should hardly have ventured to treat the whole subject, had it not been for the kind encouragement of Mr. Darwin and Professor Newton, who, about six years ago, both suggested that I should undertake the task. I accordingly set to work; but soon became discouraged by the great dearth of materials in many groups, the absence of general systematic works, and the excessive confusion that pervaded the classification. Neither was it easy to decide on any satisfactory method of treating the subject. During the next two years, however, several important catalogues and systematic treatises appeared, which induced me to resume my work; and during the last three years it has occupied a large portion of my time.

After much consideration, and some abortive trials, an outline plan of the book was matured; and as this is, so far as I am aware, quite novel, it will be well to give a few of the reasons for adopting it.

Most of the previous writings on Geographical Distribution appeared to me to be unsatisfactory, because they drew their conclusions from a more or less extensive *selection* of facts; and did not clearly separate groups of facts of unequal value, or those relating to groups of animals of unequal rank. As an example of what is meant, I may refer to Mr. Andrew Murray's large and valuable work on the Geographical Distribution of Mammalia, in which an immense number of coloured maps are

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used to illustrate the distribution of various groups of animals. These maps are not confined to groups of any fixed rank, but are devoted to a selection of groups of various grades. Some show the range of single species of a genus—as the lion, the tiger, the puma, and a species of fox; others are devoted to sections of genera,—as the true wolves; others to genera,—as the hyænas, and the bears; others to portions of families,—as the flying squirrels, and the oxen with the bisons; others to families, —as the Mustelidæ, and the Hystricidæ; and others to groups of families or to orders,—as the Insectivora, and the opossums with the kangaroos. But in no one grade are all the groups treated alike. Many genera are wholly unnoticed, while several families are only treated in combination with others, or are represented by some of the more important genera.

In making these observations I by no means intend to criticise Mr. Murray's book, but merely to illustrate by an example, the method which has been hitherto employed, and which seems to me not well adapted to enable us to establish the foundations of the science of distribution on a secure basis To do this, uniformity of treatment appeared to me essential, both as a matter of principle, and to avoid all imputation of a partial selection of facts, which may be made to prove anything. I determined, therefore, to take in succession every well-established family of terrestrial vertebrates, and to give an account of the distribution of all its component genera, as far as materials were available. Species, as such, are systematically disregarded, —firstly, because they are so numerous as to be unmanageable; and, secondly, because they represent the most recent modifications of form, due to a variety of often unknown causes, and are therefore not so clearly connected with geographical changes as are the natural groups of species termed genera; which may be considered to represent the average and more permanent

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distribution of an organic type, and to be more clearly influenced by the various known or inferred changes in the organic and physical environment.

This systematic review of the distribution of families and genera, now forms the last part of my book—Geographical Zoology; but it was nearly the first written, and the copious materials collected for it enabled me to determine the zoo-geographical divisions of the earth (regions and sub-regions) to be adopted. I next drew up tables of the families and genera found in each region and sub-region; and this afforded a basis for the geographical treatment of the subject—Zoological Geography—the most novel, and perhaps the most useful and generally interesting part of my work. While this was in progress I found it necessary to make a careful summary of the distribution of extinct Mammalia. This was a difficult task, owing to the great uncertainty that prevails as to the affinities of many of the fossils, and my want of practical acquaintance with Palæontology; but having carefully examined and combined the works of the best authors, I have given what I believe is the first connected sketch of the relation of extinct Mammalia to the distribution of living groups, and have arrived at some very interesting and suggestive results.

It will be observed that man is altogether omitted from the series of the animal kingdom as here given, and some explanation of this omission may perhaps be required. If the genus *Homo* had been here treated like all other genera, nothing more than the bare statement—"universally distributed"—could have been given;—and this would inevitably have provoked the criticism that it conveyed no information. If, on the other hand, I had given an outline of the distribution of the *varieties* or *races* of man, I should have departed from the plan of my work for no sufficient reason. Anthropology is a science

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by itself; and it seems better to omit it altogether from a zoological work, than to treat it in a necessarily superficial manner.

The best method of illustrating a work of this kind was a matter requiring much consideration. To have had a separate coloured or shaded map for each family would have made the work too costly, as the terrestrial vertebrates alone would have required more than three hundred maps. I had also doubts about the value of this mode of illustration, as it seemed rather to attract attention to details than to favour the development of general views. I determined therefore to adopt a plan, suggested in conversation by Professor Newton; and to have one general map, showing the regions and sub-regions, which could be referred to by means of a series of numbers. These references I give in the form of diagrammatic headings to each family; and, when the map has become familiar, these will, I believe, convey at a glance a body of important information.

Taking advantage of the recent extension of our knowledge of the depths of the great oceans, I determined to give upon this map a summary of our knowledge of the contours of the ocean bed, by means of tints of colour increasing in intensity with the depth. Such a map, when it can be made generally accurate, will be of the greatest service in forming an estimate of the more probable changes of sea and land during the Tertiary period; and it is on the effects of such changes that any satisfactory explanation of the facts of distribution must to a great extent depend.

Other important factors in determining the actual distribution of animals are, the zones of altitude above the sea level, and the strongly contrasted character of the surface as regards vegetation—a primary condition for the support of animal life. I

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therefore designed a series of six maps of the regions, drawn on a uniform scale, on which the belts of altitude are shown by contour-shading, while the forests, pastures, deserts, and perennial snows, are exhibited by means of appropriate tints of colour.

These maps will, I trust, facilitate the study of geographical distribution as a science, by showing, in some cases, an adequate cause in the nature of the terrestrial surface for the actual distribution of certain groups of animals. As it is hoped they will be constantly referred to, double folding has been avoided, and they are consequently rather small; but Mr. Stanford, and his able assistant in the map department, Mr. Bolton, have taken great care in working out the details from the latest observations; and this, combined with the clearness and the beauty of their execution, will I trust render them both interesting and instructive.

In order to make the book more intelligible to those readers who have no special knowledge of systematic zoology, and to whom most of the names with which its pages are often crowded must necessarily be unmeaning, I give a series of twenty plates, each one illustrating at once the physical aspect and the special zoological character of some well-marked division of a region. Great care has been taken to associate in the pictures, such species only as do actually occur together in nature; so that each plate represents a scene which is, at all events, not an impossible one. The species figured all belong to groups which are either peculiar to, or very characteristic of, the region whose zoology they illustrate; and it is hoped that these pictures will of themselves serve to convey a notion of the varied types of the higher animals in their true geographical relations. The artist, Mr. J. B. Zwecker, to whose talent as a zoological draughtsman and great knowledge both of animal and vegetable forms we are indebted for this set of drawings, died a few weeks after he

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had put the final touches to the proofs. He is known to many readers by his vigorous illustrations of the works of Sir Samuel Baker, Livingstone, and many other travellers,—but these, his last series of plates, were, at my special request, executed with a care, delicacy, and artistic finish, which his other designs seldom exhibit. It must, however, be remembered, that the figures of animals here given are not intended to show specific or generic characters for the information of the scientific zoologist, but merely to give as accurate an idea as possible, of some of the more remarkable and more restricted types of beast and bird, amid the characteristic scenery of their native country;—and in carrying out this object there are probably few artists who would have succeeded better than Mr. Zwecker has done.

The general arrangement of the separate parts of which the work is composed, has been, to some extent, determined by the illustrations and maps, which all more immediately belong to Part III. It was at first intended to place this part last, but as this arrangement would have brought all the illustrations into the second volume, its place was changed,—perhaps in other respects for the better, as it naturally follows Part II. Yet for persons not well acquainted with zoology, it will perhaps be advisable to read the more important articles of Part IV. (and especially the observations at the end of each order) after Part II., thus making Part III. the conclusion of the work.

Part IV. is, in fact, a book of reference, in which the distribution of all the families and most of the genera of the higher animals, is given in systematic order. Part III. is treated somewhat more popularly; and, although it is necessarily crowded with scientific names (without which the inferences

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and conclusions would have nothing solid to rest on), these may be omitted by the non-scientific reader, or merely noted as a certain number or proportion of peculiar generic types. Many English equivalents to family and generic names are, however, given; and, assisted by these, it is believed that any reader capable of understanding Lyell's "Principles," or Darwin's "Origin," will have no difficulty in following the main arguments and appreciating the chief conclusions arrived at in the present work.

To those who are more interested in facts than in theories, the book will serve as a kind of dictionary of the geography and affinities of animals. By means of the copious Index, the native country, the systematic position, and the numerical extent of every important and well established genus of land-animal may be at once discovered;—information now scattered through hundreds of volumes.

In the difficult matters of synonymy, and the orthography of generic names, I have been guided rather by general utility than by any fixed rules. When I have taken a whole family group from a modern author of repute, I have generally followed his nomenclature throughout. In other cases, I use the names which are to be found in a majority of modern authors, rather than follow the strict rule of priority in adopting some newly discovered appellation of early date. In orthography I have adopted all such modern emendations as seem coming into general use, and which do not lead to inconvenience; but where the alteration is such as to completely change the pronunciation and appearance of a well-known word, I have not adopted it. I have also thought it best to preserve the initial letter of well-known and old-established names, for convenience of reference to the Indices of established works. As an example I may refer to *Epicurus*,—a name which has been in use nearly half a

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century, and which is to be found under the letter *E*, in Jerdon's Birds of India, Blyth's Catalogue, Bonaparte's Conspectus, and the Proceedings of the Zoological Society of London down to 1865. Classicists now write *Henicurus* as the correct form; but this seems to me one of those cases in which orthographical accuracy should give way to priority, and still more to convenience.

In combining and arranging so much detail from such varied sources, many errors and omissions must doubtless have occurred. Owing to my residence at a distance from the scientific libraries of the metropolis, I was placed at a great disadvantage; and I could hardly have completed the work at all, had I not been permitted to have a large number of volumes at once, from the library of the Zoological Society of London, and to keep them for months together;—a privilege for which I return my best thanks to Mr. Sclater the Secretary, and to the Council.

Should my book meet with the approval of working naturalists, I venture to appeal to them, to assist me in rendering any future editions more complete, by sending me (to the care of my publishers) notes of any important omissions, or corrections of any misstatements of fact; as well as copies of any of their papers or essays, and especially of any lists, catalogues, and monographs, containing information on the classification or distribution of living or extinct animals.

To the many friends who have given me information or assistance I beg to tender my sincere thanks. Especially am I indebted to Professor Newton, who not only read through much of my rough MSS., but was so good as to make numerous corrections and critical notes. These were of great value to me, as they often contained or suggested important additional matter, or pointed out systematic and orthographical inaccuracies.

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Professor Flower was so good as to read over my chapters on extinct animals, and to point out several errors into which I had fallen.

Dr. Günther gave me much valuable information on the classification of reptiles, marking on my lists the best established and most natural genera, and referring me to reliable sources of information.

I am also greatly indebted to the following gentlemen for detailed information on special subjects :—

To Sir Victor Brooke, for a MS. arrangement of the genera of Bovidæ, with the details of their distribution:

To Mr. Dresser, for lists of the characteristic birds of Northern and Arctic Europe:

To Dr. Hooker, for information on the colours and odours of New Zealand plants:

To Mr. Kirby, for a list of the butterflies of Chili:

To Professor Mivart, for a classification of the Batrachia, and an early proof of his article on "Apes" in the Encyclopedia Britannica:

To Mr. Salvin, for correcting my list of the birds of the Galapagos, and for other assistance:

To Mr. Sharpe, for MS. lists of the birds of Madagascar and the Cape Verd Islands:

To Canon Tristram, for a detailed arrangement of the difficult family of the warblers,—Sylviidæ:

To Viscount Walden, for notes on the systematic arrangement of the Pycnonotidæ and Timaliidæ, and for an early proof of his list of the birds of the Philippine Islands.

I also have to thank many naturalists, both in this country and abroad, who have sent me copies of their papers; and I trust they will continue to favour me in the same manner.

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An author may easily be mistaken in estimating his own work. I am well aware that this first outline of a great subject is, in parts, very meagre and sketchy; and, though perhaps overburthened with some kinds of detail, yet leaves many points most inadequately treated. It is therefore with some hesitation that I venture to express the hope that I have made some approach to the standard of excellence I have aimed at;—which was, that my book should bear a similar relation to the eleventh and twelfth chapters of the "Origin of Species," as Mr. Darwin's "Animals and Plants under Domestication" does to the first chapter of that work. Should it be judged worthy of such a rank, my long, and often wearisome labours, will be well repaid.

March, 1876.

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ERRATA IN VOL. I.

I have detected several misprints and small errors in the final impression, and Dr. Meyer, who has translated the work into German, has kindly communicated all that he has noticed. It is not thought necessary to give here all the smaller orthographical errors, most of which will be corrected in the Index. The following seem, however, to be of sufficient importance to justify me in asking my readers to correct them in their copies.

Page 93, 12 lines from foot, *for* Hocco *read* Hoazin.
,, 97, line 2, *for* Hocco *read* Hoazin.
,, 147, 13 lines from foot, *for* three-handed *read* three-banded.
,, 177, line 6, *for* Lycænidæ *read* Zygænidæ.
,, 183, line 20, *for* third *read* fourth.
,, 233, line 18, *for* Spirigidea *read* Sphingidea.
,, 242, *insert* | 92a | Tamias | 1 | All Northern Asia | N. America.
,, 245, last line, *insert in 2nd column* (6).
,, 309, line 20, *for* Motacilla *read* Budytes.
,, 327, 12 lines from foot, *after* Hindostan *read* and.
,, 331, last line, for *Ichyopsis* read *Ichthyophis*.
,, 340, line 15, for *Edolius* read *Bhringa*.
,, 348, line 17, *for* Flores *read* New Guinea.
,, 371, 11 lines from foot, *for* and Borneo *read* Borneo and Philippines.
,, 391, 10 lines from foot, *after* Celebes *add* and the Papuan Islands.
,, 391, 9 lines from foot, *omit* New Guinea or.
,, 414, 6 lines from foot, for *Epimachus* read *Seleucides*.
,, 415, line 10 *for* ditto *read* ditto.
,, 427, line 20, *after* Celebes *add* and on some of the Philippine Islands.
,, 427, 5 lines from foot, *for* tusks *read* jaw.
,, 462, 15 lines from foot, *for* p. 156 *read* p. 166.
,, 474, 9 lines from foot, *after* Celebes *add* Papua.

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CHAPTER VII.

EXTINCT MAMMALIA OF THE NEW WORLD.

THE discoveries of very rich deposits of mammalian remains in various parts of the United States have thrown great light on the relations of the faunas of very distant regions. North America now makes a near approach to Europe in the number and variety of its extinct mammalia, and in no part of the world have such perfect specimens been discovered. In what are called the "Mauvaises terres" of Nebraska (the dried-up mud of an ancient lake), thousands of entire crania and some almost entire skeletons of ancient animals have been found, their teeth absolutely perfect, and altogether more resembling the preparations of the anatomist, than time-worn fossils such as we are accustomed to see in the museums of Europe. Other deposits have been discovered in Oregon, California, Virginia, South Carolina, Texas, and Utah, ranging over all the Tertiary epochs, from Post-Pliocene to Eocene, and furnishing a remarkable picture of the numerous strange mammalia which inhabited the ancient North American continent.

NORTH AMERICA—POST-PLIOCENE PERIOD.

Insectivora.—The only indications of this order yet discovered, consists of a single tooth of some insectivorous animal found in Illinois, but which cannot be referred to any known group.

Carnivora.—These are fairly represented. Two species of *Felis* as large as a lion; the equally large extinct *Trucifelis*, found only in Texas; four species of *Canis*, some of them larger

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than wolves; two species of *Galera*, a genus now confined to the Neotropical region; two bears, and an extinct genus, *Arctodus;* an extinct species of racoon (*Procyon*), and an allied extinct genus, *Myxophagus*—show, that at a very recent period North America was better supplied with Carnivora than it is now. Remains of the walrus (*Trichechus*) have also been found as far south as Virginia.

Cetacea.—Three species of dolphins belonging to existing genera, have been found in the Eastern States; and two species of *Manatus*, or sea-cow, in Florida and South Carolina.

Ungulata.—Six extinct horses (*Equus*), and one *Hipparion;* the living South American tapir, and a larger extinct species; a *Dicotyles*, or peccary, and an allied genus, *Platygonus;* a species of the South American llamas (*Auchenia*), and one of a kind of camel, *Procamelus;* two extinct bisons; a sheep, and two musk-sheep (*Ovibos*); with three living and one extinct deer (*Cervus*), show an important increase in its Herbivora.

Proboscidea.—Two elephants and two mastodons, added to this remarkable assemblage of large vegetable-feeding quadrupeds.

Rodentia.—These consist mainly of genera and species still living in North America; the only important exceptions being a species of the South American capybara (*Hydrochærus*) in South Carolina; and *Præotherium*, an extinct form of hare, found in a bone cave in Pennsylvania.

Edentata.—Here we meet with a wonderful assemblage, of six species belonging to four extinct genera, mostly of gigantic size. A species of *Megatherium*, three of *Megalonyx*, and one of *Mylodon*—huge terrestrial sloths as large as the rhinoceros or even as the largest elephants—ranged over the Southern States to Pennsylvania, the latter (*Mylodon*) going as far as the great lakes and Oregon. Another form, *Ereptodon*, has been found in the Mississippi Valley.

Marsupialia.—The living American genus of opossums, *Didelphys*, has been found in deposits of this age in South Carolina.

Remarks on the Post-Pliocene fauna of North America.—The assemblage of animals proved, by these remains, to have

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inhabited North America at a comparatively recent epoch, is most remarkable. In Europe, we found a striking change in the fauna at the same period; but that consisted almost wholly in the presence of animals now inhabiting countries immediately to the north or south. Here we have the appearance of two new assemblages of animals, the one now confined to the Old World—horses, camels, and elephants; the other exclusively of South American type—llamas, tapirs, capybaras, *Galera*, and gigantic Edentata. The age of the various deposits in which these remains are found is somewhat uncertain, and probably extends over a considerable period of time, inclusive of the Glacial epoch, and perhaps both anterior and subsequent to it. We have here, as in Europe, the presence and apparent co-existence in the same area, of Arctic and Southern forms—the walrus and the manatee—the musk-sheep and the gigantic sloths. Unfortunately, as we shall see, the immediately preceding Pliocene deposits of North America are rather poor in organic remains; yet it can hardly be owing to the imperfection of the record of this period, that *not one* of the South American types above numerated occurs there, while a considerable number of Old World forms are represented. Neither in the preceding wonderfully rich Miocene or Eocene periods, does any *one* of these forms occur; or, with the exception of *Morotherium*, from Pliocene deposits *west* of the Rocky Mountains, any apparent ancestor of them! We have here unmistakable evidence of an extensive immigration from South into North America, not very long before the beginning of the Glacial epoch. It was an immigration of types altogether new to the country, which spread over all the southern and central portions of it, and established themselves sufficiently to leave abundance of remains in the few detached localities where they have been discovered. How such large yet defenceless animals as tapirs and great terrestrial sloths, could have made their way into a country abounding in large felines equal in size and destructiveness to the lion and the tiger, with numerous wolves and bears of the largest size, is a great mystery. But it is nevertheless certain that they did so; and the fact that no such

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migration had occurred for countless preceding ages, proves that some great barrier to the entrance of terrestrial mammalia which had previously existed, must for a time have been removed. We must defer further discussion of this subject till we have examined the relations of the existing faunas of North and South America.

Tertiary Period.

When we get to remains of the Tertiary age, especially those of the Miocene and Eocene epochs, we meet with so many interesting and connected types, and such curious relations with living forms in Europe, that it will be clearer to trace the history of each order and family throughout the Tertiary period, instead of considering each of the subdivisions of that period separately.

It will be well however first to note the few American Post-Pliocene or living genera that are found in the Pliocene beds. These consist of several species of *Canis*, from the size of a fox to that of a large wolf; a *Felis* as large as a tiger; an Otter (*Lutra*); several species of *Hipparion*; a peccary (*Dicotyles*); a deer (*Cervus*); several species of *Procamelus*; a mastodon; an elephant; and a beaver (*Castor*). It thus appears that out of nearly forty genera found in the Post-Pliocene deposits, only ten are found in the preceding Pliocene period. About twelve additional genera, however, appear there, as we shall see in going over the various orders.

Primates.—Among the vast number of extinct mammalia discovered in the Tertiary deposits of North America, no example of this order had been recognized up to 1872, when the discovery of more perfect remains showed, that a number of small animals of obscure affinities from the Lower Eocene of Wyoming, were really allied to the lemurs and perhaps also to the marmosets, the lowest form of American monkeys, but having a larger number of teeth than either. A number of other remains of small animals from the same formation, previously supposed to be allied to the Ungulata, are now shown to

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belong to the Primates; so that no less than twelve genera of these animals are recognized by Mr. Marsh, who classes them in two families—Limnotheridæ, comprising the genera *Limnotherium*, (which had larger canine teeth), *Thinolestes*, *Telmatolestes*, *Mesacodon*, *Bathrodon*, and *Anticodon* of Marsh, with *Notharctos*, *Hipposyus*, *Microsyops*, and *Palæacodon* previously described by Leidy;—and Lemuravidæ, consisting of the genera *Lemuravus* (Marsh) and *Hyopsodus* (Leidy). The animals of the latter family were most allied to existing lemurs, but were a more generalized form, *Lemuravus* having forty-four teeth, the greatest number known in the order. These numerous forms ranged from the size of a small squirrel to that of a racoon. It is especially interesting to find these peculiar lemuroid forms in America, just when a lemur has been discovered of about the same age in Europe; and as the American forms are said to show an affinity with the South American marmosets, while the European animal is most allied to a West African group, we have evidently not yet got back far enough to find the primeval or ancestral type from which all the Primates sprang.

About the same time, in the succeeding Miocene formation, true monkeys were discovered. Mr. Marsh describes *Laopithecus* as an animal nearly the size of the largest South American monkeys, and allied both to the Cebidæ and the Eocene Limnotheridæ. Mr. Cope has described *Menotherium* from the Miocene of Colorado, as a lemuroid animal, the size of a cat, and perhaps allied to *Limnotherium*. More Miocene remains will, no doubt, be discovered, by which we shall be enabled to trace the origin of some of the existing forms of South American monkeys; and perhaps help to decide the question (now in dispute among anatomists) whether the lemurs are really Primates, or form an altogether distinct and isolated order of mammalia.

Insectivora.—This order is represented by comparatively few forms in the tertiary beds, and these are all very different from existing types. In the Upper Miocene of Dakota are found remains indicating two extinct genera, *Lepictis* and *Ictops*. In the Miocene of Colorado, Professor Cope has recently discovered four new genera, *Isacis*; allied to the preceding, but as large as a

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Mephitis or skunk; *Herpetotherium*, near the moles; *Embasis*, more allied to the shrews; and *Domnina*, of uncertain affinities. Two others have been found in the Eocene of Wyoming; *Amomys*, having some resemblance to hedgehogs and to the Eastern *Tupaia*; and *Washakius*, of doubtful affinities.

Far back in the Triassic coal of North Carolina has been found the jaw of a small mammal (*Dromotherium*), the teeth of which somewhat resemble those of the Australian *Myrmecobius*, and may belong either to the Insectivora or Marsupials; if indeed, at that early period these orders were differentiated.

Carnivora.—The most ancient forms of this order are some remains found in the Middle Eocene of Wyoming, and others recently described by Professor Cope (1875) from the Eocene of New Mexico, of perhaps earlier date. The former consist of three genera, *Patriofelis*, *Uintacyon*, and *Sinopa*,—animals of large size but which cannot be classed in any existing family; and two others, *Mesonyx* and *Synoplotherium*, believed by Mr. Cope to be allied to *Hyænodon*. The latter consist of four genera,—*Oxyæna*, consisting of several species, some as large as a jaguar, was allied to *Hyænodon* and *Pterodon*; *Pachyæna*, allied to the last; *Prototomus*, allied to *Amphicyon* and the Viverridæ; and *Limnocyon*, a civet-like carnivore with resemblances to the Canidæ.

In the Miocene formations we find the Feline type well developed. The wonderful *Machairodus*, which in Europe lived down to Post-Pliocene times, is found in the Upper Miocene of Dakota; and perfect crania have been discovered, showing that the chin was lengthened downwards to receive and protect the enormous canines. *Dinictis* was allied both to *Machairodus* and to the weasels. Three new genera have been lately described by Professor Cope from the Miocene of Colorado,—*Bunælurus*, with characters of both cats and weasels; *Daptophilus*, allied to *Dinictis*; and *Hoplophoneus*, more allied to *Machairodus*. The Canidæ are represented by *Amphicyon*, which occurs in deposits of the same age in Europe; and by *Canis*, four species of which genus are recorded by Professor Cope from the Miocene of Colorado, and it also occurs in the Pliocene. The *Hyænodon* is represented by three species in the Miocene of Dakota and Colorado. It occurs

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also in the European Miocene and Upper Eocene formations, and constitutes a distinct family Hyænodontidæ, allied, according to Dr. Leidy, to wolves, cats, hyænas and weasels. The Ursidæ are represented by only one species of an extinct genus, *Leptarchus*, from the Pliocene of Nebraska. From the Pliocene of Colorado, Prof. Cope has recently described *Tomarctos*, as a "short-faced type of dog;" as well as species of *Canis* and *Martes*.

Ungulata.—The animals belonging to this order being usually of large size and accustomed to feed and travel in herds, are liable to wholesale destruction by floods, bogs, precipices, drought or hunger. It is for these reasons, probably, that their remains are almost always more numerous than those of other orders of mammalia. In America they are especially abundant; and the number of new and intermediate types about whose position there is much difference of opinion among Palæontologists, renders it very difficult to give a connected summary of them with any approach to systematic accuracy.

Beginning with the Perissodactyla, or odd-toed ungulates, we find the Equine animals remarkably numerous and interesting. The true horses of the genus *Equus*, so abundant in the Post-Pliocene formations, are represented in the Pliocene by several ancestral forms. The most nearly allied to *Equus* is *Pliohippus*, consisting of animals about the size of an ass, with the lateral toes not externally developed, but with some differences of dentition. Next come *Protohippus* and *Hipparion*, in which the lateral toes are developed but are small and functionless. Then we have the allied genera, *Anchippus*, *Merychippus*, and *Hyohippus*, related to the European *Hippotherium*, which were all still smaller animals, *Protohippus* being only 2½ feet high. In the older deposits we come to a series of forms, still unmistakably equine, but with three or more toes used for locomotion and with numerous differentiations in form, proportions, and dentition. These constitute the family Anchitheridæ. In the Miocene we have the genera *Anchitherium* (found also in the European Miocene), *Miohippus* and *Mesohippus*, all with three toes on each foot, and about the size of a sheep or large goat. In the Eocene of

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Utah and Wyoming, we get a step further back, several species having been discovered about the size of a fox with four toes in front and three behind. These form the genus *Orohippus*, and are the oldest ancestral horse known. Prof. Marsh points out the remarkably perfect series of forms in America, which, beginning with this minute ancient type, is gradually modified by gaining increased size, increased speed by concentration of the limb-bones, elongation of the head and neck, the canine teeth decreased in size, the molars becoming longer and being coated with cement—till we at last come to animals hardly distinguishable, specifically, from the living horse.

Allied to these, are a series of forms showing a transition to the tapirs, and to the *Palæotherium* of the European Eocene. In the Pliocene we have *Parahippus;* in the Miocene *Lophiodon*, found in the same formation and in the Eocene of Europe, and allied to the tapir; and in the Eocene, *Palæosyops*, as large as a rhinoceros, which had large canines and was allied to the tapir and *Palæotherium; Limnohyus*, forming the type of a family Limnohyidæ, which included the last genus and some others mentioned further on; and *Hyrachyus*, allied to *Lophiodon*, and to *Hyracodon* an extinct form of rhinoceros. Besides these we have *Lophiotherium* (also from the Eocene of Europe); *Diplacodon* allied to *Limnohyus*, but with affinities to modern Perissodactyla and nearly as large as a rhinoceros; and *Colonoceras*, also belonging to the Limnohyidæ, an animal which was the size of a sheep, and had divergent protuberances or horns on its nose. A remarkable genus, *Bathmodon*, lately described by Professor Cope, and of which five species have been found in the Eocene of New Mexico and Wyoming, is believed to form the type of a new family, having some affinity to *Palæosyops* and to the extinct Brontotheridæ. It had large canine tusks but no horns.

The Rhinocerotidæ are represented in America by the genus *Rhinoceros* in the Pliocene and Miocene, and by *Aceratherium* and *Hyracodon* in the Miocene. Both the latter were hornless, and *Hyracodon* was allied to the Eocene *Hyrachyus*, one of the Lophiodontidæ. In the Eocene and Miocene deposits of Utah, and Oregon, several remarkable extinct rhinoceroses have been

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recently discovered, forming the genus *Diceratherium*. These had a pair of nasal horns placed side by side on the snout, not behind each other as in existing two-horned rhinoceroses, the rest of their skeleton resembling the hornless *Aceratherium*. They were of rather small size.

Next to these extinct rhinoceroses come the Brontotheridæ, an extraordinary family of large mammalia, some of which exceeded in bulk the largest living rhinoceros. They had four toes to the front and three to the hind feet, with a pair of large divergent horns on the front of the head, in both sexes. Professor Marsh and Dr. Leidy have described four genera, *Brontotherium*, *Titanotherium*, *Megacerops*, and *Anisacodon*, distinguished by peculiarities of dentition. Though most nearly allied to the rhinoceroses, they show some affinity for the gigantic Dinocerata of the Eocene to be noticed further on. Professor Cope has since described another genus, *Symborodon*, from the Miocene of Colorado, with no less than seven species, one nearly the size of an elephant. He thinks they had a short tapir-like proboscis. The species differ greatly in the form of the cranium and development of the horn-bearing processes.

We commence the Artiodactyla, or even-toed Ungulates, with the hog tribe. These are represented by species of peccaries, (*Dicotyles*) from the Pliocene of Nebraska and Oregon; and by an allied form *Thinohyus*, very like *Dicotyles*, but having an additional premolar tooth and a much smaller brain-cavity. From the Miocene are three allied genera, *Nanohyus*, *Leptochærus*, and *Perchærus*. Professor Cope, however, thinks *Leptochærus* may be Lemuroid, and allied to *Menotherium*. The Anthracotheridæ, a family which connects the Hippopotamidæ and Ruminants, and which occurs in the Miocene of Europe and India, are represented in America by the genus *Hyopotamus* from the Miocene of Dakota, and *Elotherium* from the Miocene of Oregon and the Eocene of Wyoming; the latter genus being sometimes classed with the preceding family, and lately placed by Professor Marsh, in the new order, Tillodontia. Professor Cope has since described three other genera from the Eocene of New

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Mexico: *Meniscotherium*, having resemblances to *Palæosyops*, *Hyopotamus*, and the Limnotheridæ; *Phenacodus*, the size of a hog, of doubtful position, but perhaps near *Elotherium*; and *Achænodon*, as large as a cow, but more hog-like than the preceding. Another new genus from the Miocene of Colorado—*Pelonax*—is said by Professor Cope to come between *Elotherium* and *Hippopotamus*.

The Camelidæ are very abundant, and form one of the most striking features of the ancient fauna of America. *Procamelus*, *Homocamelus*, and *Megalomeryx*, are extinct genera found in the Pliocene formation; the first very closely allied to the Old World camel, the last smaller and more sheep-like. In the Miocene two other genera occur, *Pœbrotherium* and *Protomeryx*, the former allied to both the camel and the llama.

Deer are represented by a single species of *Cervus* in the Pliocene, while two extinct genera, *Leptomeryx* and *Merycodus*, are found in the Miocene deposits, the latter indicating a transition between camels and deer. Two other genera, *Hypisodus* and *Hypertragulus*, of very small size, are said by Professor Cope to be allied to the Tragulidæ and to *Leptomeryx*.

The Bovidæ, or hollow-horned ruminants, are only represented in the Newer Pliocene by a single species of an extinct genus, *Casoryx*, said to be intermediate between antelopes and deer.

We now come to an exclusively American family, the *Oreodontidæ*, which consisted of small animals termed by Dr. Leidy, "ruminating hogs," and which had some general structural resemblances to deer and camels. They abounded in North America during the Pliocene, and especially during the Miocene epoch, no less than six genera and twenty species having been discovered. *Merychus* contains the Pliocene forms; while *Oreodon*, *Eporeodon*, *Merychochœrus*, *Leptauchenia*, and *Agriochœrus* are Miocene. The last genus extends back into the Eocene period, and shows affinity to the European Anoplotheridæ of the same epoch.

Proboscidea.—The Elephantidæ are only represented in America by one species of *Mastodon* and one of *Elephas*, in the Newer Pliocene deposits. In the Older Pliocene, Miocene,

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and Upper Eocene, no remains of this order have been found; and in 1869, Dr. Leidy remarked on the small average size of the extinct North American mammalia, which were almost all smaller than their living analogues. Since then, however, wonderful discoveries have been made in deposits of Middle Eocene age in Wyoming and Colorado, of a group of huge animals not only rivalling the elephants in size, but of so remarkable and peculiar a structure as to require the formation of a new order of mammals—Dinocerata—for their reception.

This order consists of animals with generalised Ungulate and Proboscidean affinities. The lower jaw resembles that of the hippopotamus; they had five toes on the anterior feet and four on the posterior; three pairs of horns, the first pair on the top of the head, large and perhaps palmated, the second pair above the eyes, while the third and smallest stood out sideways on the snout. They had enormous upper canines, of which the roots entered the middle horn cores, no upper incisors, and small molars. Professor Marsh believes that they had no trunk. The remains discovered indicate four genera, *Dinoceras* (3 sp.), *Tinoceras* (2 sp.), *Uintatherium* (1 sp.), and *Eobasileus* (2 sp.). Many other names have been given to fragments of these animals, and even those here given may not be all distinct.

Another new order, Tillodontia, recently established by Professor Marsh, is perhaps yet more remarkable in a zoological point of view, since it combines the characters of Carnivora, Ungulata, and Rodents. These animals have been formed into two families, Tillotheridæ and Stylinodontidæ; and three genera, *Tillotherium*, *Anchippodus*, and *Stylinodontia*. All are from the Eocene of Wyoming and New Jersey. Perhaps to these must be added *Elotherium* from the Miocene of Dakota, the other forms being all Eocene. They were mostly animals of small size, between that of the capybara and tapir. The skull resembled in form that of a bear; the molar teeth were of Ungulate type, and the incisors like those of a Rodent; but the skeleton was more that of the Ursidæ, the feet being plantigrade. Professor Cope has since described three new genera from the Eocene of New Mexico, *Ectoganus*, *Calamodon*, and *Esthonyx*, comprising

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seven species allied to *Tillotherium* and *Anchippodus*, and having also relations, as Professor Cope believes, with the South American Toxodontidæ.

Rodentia.—This order is represented in the Pliocene by a beaver, a porcupine, and an American mouse (*Hesperomys*), all extinct species of living genera, the *Hystrix* being an Old World type; and Professor Cope has recently described *Panolax*, a new genus of hares from the Pliocene of New Mexico. The Miocene deposits have furnished an extinct genus allied to the hares—*Palæolagus;* one of the squirrel family—*Ischyromys;* a small extinct form of beaver—*Palæocastor;* and an extinct mouse—*Eumys*. The Eocene strata of Wyoming have lately furnished two extinct forms of squirrel, *Paramys* and *Sciuravus;* and another of the Muridæ (or mouse family), *Mysops*.

Cetacea.—Numerous remains of dolphins and whales, belonging to no less than twelve genera, mostly extinct, have been found in the Miocene deposits of the Atlantic and Gulf States, from New Jersey to South Carolina and Louisiana; while seven genera of the extinct family, Zeuglodontidæ, have been found in Miocene and Eocene beds of the same districts. Some remains associated with these are doubtfully referred to the Seal family (Phocidæ) among the Carnivora.

Edentata.—Till quite recently no remains of this order have occurred in any North American deposits below the Post-Pliocene; but in 1874 Prof. Marsh described some remains allied to *Megalonyx* and *Mylodon*, from the Pliocene beds of California and Idaho, and forming a new genus, *Morotherium*. As these remains have only occurred to the west of the Rocky Mountains, and in Pliocene deposits whose exact age is not ascertained, they hardly affect the remarkable absence of this group from the whole of the exceedingly rich Tertiary deposits in all other parts of North America.

General Relations of the extinct Tertiary Mammalia of North America and Europe.—Having now given a sketch of the extinct Mammalia which inhabited Europe and North America during the Tertiary period, we are enabled by comparing them,

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to ascertain their relations to each other, and to see how far they elucidate the problem of the birth-place and subsequent migrations of the several families and genera. We have already pointed out the remarkable features of the Quaternary (or Post-Pliocene) fauna of North America, and now proceed to discuss that of the various Tertiary periods, which is closely connected with the extinct fauna of Europe.

The Tertiary Mammalia of North America at present described belong to from eighty to one hundred genera, while those of Europe are nearly double that number; yet only eighteen genera are common to the two faunas, and of these eight are living and belong chiefly to the Pliocene period. Taking first, the genera which in America do not go back beyond the Pliocene period (ten in number), we find that eight of them in Europe go back to the Upper Miocene. These are *Felis*, *Pseudælurus*, *Hipparion*, *Cervus*, *Mastodon*, *Elephas* (in India), *Castor* and *Hystrix*; while another, *Canis*, goes back to the Upper Eocene and the tenth, *Equus*, confined to the newer Pliocene or perhaps to the Post-Pliocene in America, extends back to the older Pliocene in Europe. Of the seven European genera which are confined to the Miocene period in America, three, *Hyænodon*, *Anchitherium*, and *Lophiodon* go back to the Eocene in Europe; three others, *Machairodus*, *Rhinoceros*, and *Aceratherium*, are also of Miocene age in Europe; *Amphicyon* goes back to the Lower Miocene of Europe. *Lophiotherium* belongs to the Eocene of both countries.

If we turn now to families instead of genera, we find that the same general rule prevails. Mustelidæ (weasels), Ursidæ (bears), true Equidæ (horses), and Bovidæ (oxen &c.), go no further back in America than the Pliocene, while they all go back to the Miocene in Europe. Suidæ (swine) and Anoplotheridæ (extinct) are found in the American Miocene and in the European Eocene. Anchitheridæ (extinct) reach the Upper Eocene in America, while in Europe they range through Upper, Middle, and Lower Eocene. Cervidæ (deer) alone are Miocene in both countries. There remain two families in which America has the pre-eminence. Camelidæ (camels) were wonderfully developed in

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the American Pliocene and Miocene periods, abounding in genera and species; whereas in Europe the group only exists in the Post-Pliocene or Lower Pliocene, with one Upper Miocene species of *Camelus* in N. India. The Anthracotheridæ (extinct), found only in the Upper Miocene of France and India, reach even the Lower Eocene in America.

These facts may be due, in part, to a want of strict co-ordination between the Tertiary deposits of Europe and North America, —in part to the imperfection of the record in the latter country. Yet it does not seem probable that they are altogether due to these causes, because the Miocene beds, which are by far the best known in America as in Europe, exhibit deficiencies of the same kind as the less known Eocene deposits. The fossil fauna of both countries is so rich, that we can hardly impute great and well marked differences to imperfect knowledge; yet we find such important families as the Civets, Hyænas, Giraffes, and Hippopotami absent from America, with the Weasels, and Antelopes almost so; while America possesses almost all the Camelidæ, two peculiar orders, Dinocerata and Tillodontia, and four remarkably peculiar families, Limnotheridæ, Lemuravidæ, Oreodontidæ and Brontotheridæ. If then the facts at present known represent approximately the real time-relations of the groups in question on the two continents, they render it probable that weasels, bears, true horses, swine, oxen, sheep and antelopes, originated on the Old World continent, and were transmitted to America during some part of the Miocene period; while camels originated in the New World, and somewhere about the same time passed over to Europe. Of the extinct families common to the two hemispheres, the Anthracotheridæ alone seem to have had an American origin. Of the genera common to the two countries, almost all seem to have had a European origin, the only genera of equal date being the two rhinoceroses and three Anchitheridæ; but if the Brontotheridæ are allied to the Rhinocerotidæ, these latter may have originated in America, although now an exclusively Old World type. These conclusions are not improbable when we consider the much greater size of the Old World continents, extending far into the tropics and probably

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always more or less united to the tropical areas; while the evidence of the extinct mammalia themselves shows, that South America has been for the most part isolated from the northern continent, and did not take part in the development of its characteristic Tertiary fauna.

Before speculating further on this subject, it will be well to lay before our readers a summary of South American palæontology, after which we shall be in a better position to draw correct inferences from the whole body of the evidence.

South America.

Unfortunately, our knowledge of the interesting fossil fauna of this continent, is almost wholly confined to the Post-Pliocene and Pliocene periods. A few remains have been discovered in deposits believed to be of Eocene age, but nothing whatever representing the vast intervening period, so rich in peculiar forms of animal life both in North America and Europe.

Fauna of the Brazilian caves.—What we know of the Post-Pliocene period is chiefly due to the long-continued researches of Dr. Lund in the caves of Central Brazil, mostly situated in a district near the head waters of the San Francisco river in the Province of Minas Geraes. The caves are formed in limestone rocks, and are so numerous that Dr. Lund visited thousands, but only sixty contained bones in any quantity. These caves have a floor of reddish earth, often crowded with bones. In one experiment, half a cubic foot of this earth contained jaws of 400 opossums, 2,000 mice, besides remains of bats, porcupines and small birds. In another trial, the whole of the earth in a cavern was carried out for examination, amounting to 6,552 firkins; and, from a calculation made by measured samples, it was estimated to contain nearly seven millions of jaw-bones of cavies, opossums, porcupines, and mice, besides small birds, lizards, and frogs. This immense accumulation is believed to have been formed from the bodies of animals brought into the cavern by owls; and, as these are unsocial birds, the quantity found implies an

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immense lapse of time, probably some thousands of years. More than 100 species of Mammalia, in all, were obtained in these caves. Some were living species or closely allied to such; but the majority were extinct, and a considerable number, about one-fourth, belonged to extinct genera, or genera not now inhabiting South America. Stone implements and human remains were found in several of the caves with extinct animals. The following enumeration of these remains is from the corrected list of M. Gervais.

Primates.—Extinct species of *Cebus*, *Callithrix*, and *Jacchus*—South American genera of monkeys; with an extinct genus, *Protopithecus*—an animal of large size but belonging to the American family Cebidæ.

Chiroptera.—Species belonging to the South American Phyllostomidæ, and to two South American genera of other families.

Carnivora.—Five species of *Felis*, some allied to living animals, others extinct; a species of the widespread extinct genus *Machairodus*; and a small species referred to *Cynælurus*, the genus containing the hunting leopard now found only in Africa and India. Canidæ are represented by *Canis* and *Icticyon* (a living Brazilian species of the latter genus), and the extinct genus *Speothos*. Mustelidæ are represented by extinct species of the South American genera *Mephitis* and *Galictis*. Procyonidæ, by a species of *Nasua*. Ursidæ, by *Arctotherium*, a genus closely resembling, if not identical with, that containing the "spectacled bear" of Chili.

Ungulata.—*Equus*, *Tapirus*, *Dicotyles*, *Auchenia*, *Cervus*, *Leptotherium*, and *Antilope*, are the cave-genera of this order. *Equus* and *Antelope* are particularly interesting, as representing groups forming no part of existing South American zoology; while the presence also of *Leptotherium*, an extinct genus of antelopes, shows that the group was fairly represented in South America at this comparatively recent period.

Proboscidea.—A species of *Mastodon*, found also in the Pliocene of La Plata, represents this order.

Rodentia.—These abound. *Dasyprocta*, *Cœlogenys*, *Cavia*, *Kerodon*, all living genera of Caviidæ, are represented by

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extinct species. *Cercolabes*, the 'tree porcupine' (Cercolabidæ) has two species, one as large as a peccary; *Myopotamus*, *Loncheres*, *Carterodon*, are existing genera of spiny rats (Echimyidæ); and there are two extinct genera of the same family, *Lonchophorus* and *Phyllomys*. *Lagostomus* (Chinchillidæ), the viscacha of the Pampas, is represented by an extinct species. There is also an extinct species of *Lepus*; several species of *Hesperomys* and *Oxymycterus*; and a large *Arvicola*, a genus not living in South America.

Edentata.—These, which constitute the great feature of the existing South American fauna, were still more abundant and varied in the Cave period, and it is remarkable that most of them are extinct *genera*. The armadillos are alone represented by living forms, *Dasypus*, and *Xenurus*; *Eurylon* and *Heterodon*, are extinct genera of the same family, as well as *Chlamydotherium*—huge armadillos the size of a tapir or rhinoceros, and *Pachytherium*, which was nearly as large. The ant-eaters are represented only by *Glossotherium*, an extinct form allied to *Myrmecophaga* and *Manis*. The sloths were more numerous, being represented by the extinct genera *Caledon*, *Sphenodon* and *Ochotherium*, the last of large size. The huge terrestrial sloths—Megatheridæ, also abounded; there being species of *Megatherium* and *Megalonyx*, as well as the allied *Scelidotherium*, supposed to have some affinity for the African *Orycteropus*.

Marsupials.—No new forms of these appear, but numerous species of *Didelphys*, all closely allied to opossums still living in South America.

The preceding sketch of the wonderful cave fauna of Central Brazil, is sufficient to show that it represents, in the main, a period of great antiquity. Not only are almost the whole of the species extinct, but there are twenty extinct genera, and three others not now inhabitants of South America. The fact that so few remains of the living animals of the country are found in these caves, indicates that some change of physical conditions has occurred since they were the receptacles of so many of the larger animals; and the presence of many extinct genera of

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large size, especially among the Edentata and American families of Rodents, are additional proofs of a very high antiquity. Yet many of these cave animals are closely allied to those which are found in North America in the Post-Pliocene deposits only, so that we have no reason to suppose the cave-fauna to be of much earlier date. But the great amount of organic change it implies, must give us an enlarged idea of the vast periods of time, as measured by years, which are included in this, the most recent of all geological epochs.

Pliocene Period of Temperate South America.—We have now to consider the numerous remains of extinct animals found in various deposits in the Pampas, and in Patagonia, and a few in Bolivia. The age of these is uncertain; but as they are very similar to the cave-fauna, though containing a somewhat larger proportion of extinct genera and some very remarkable new forms, they cannot be *very* much older, and are perhaps best referred at present to the newer portion of the Pliocene formation.

Carnivora.—The genus *Machairodus* or sabre-toothed tigers, represents the Felidæ. There are several species of wolves (*Canis*); a weasel (*Mustela*); two bears of the Brazilian cave-genus *Arctotherium;* and the extinct European genus *Hyænarctos.*

Ungulata.—There are two species of *Equus*, found in the Pampas, Chili, and Bolivia; two of *Macrauchenia*, an extraordinary extinct group allied to the tapir and *Palæotherium*, but with the long neck, and general size of a camel. A second species found on the highlands of Bolivia is much smaller.

A more recent discovery, in Patagonia, is the almost perfect series of teeth of a large animal named *Homalodontotherium;* and which is believed by Professor Flower, who has described it, to have been allied to *Rhinoceros*, and still more to the Miocene *Hyracodon* from North America; and also to present some resemblances to *Macrauchenia*, and though much more remotely, to the curious genus *Nesodon* mentioned further on.

The Artiodactyla, or even-toed Ungulates, are represented by a species of *Dicotyles*, or peccary, found in the deposits of the

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Pampas; by *Auchenia*, or llama, of which three extinct species inhabited Bolivia, in which country two allied but extinct genera, *Palæolama* and *Camelotherium*, have also been found. Three species of deer (*Cervus*), from the Pampas deposits, complete the list of Pliocene Ungulates.

Proboscidea.—The cave species of *Mastodon* is found also in the Pampas deposits, and another in the Andes of Chili and Bolivia.

Rodents.—These are not so numerous as in the caves. There are species of the existing genera, *Kerodon* and *Cavia* (Caviidæ); *Lagostomus* (Chinchillidæ); *Ctenomys* (Octodontidæ); *Lepus* (hare); *Hesperomys* and *Oxymycterus* (Muridæ); *Arvicola*, a genus not living in South America; and an extinct genus, *Cardiodus*. There is also a remarkable extinct form, *Typotherium*, larger than the capybara, and having affinities to Edentates and Ungulates. Three species have been found in the Pampas deposits.

Edentata.—These are as abundant and remarkable as in the cave deposits. *Scelidotherium*, *Megatherium*, *Megalonyx*, *Glossotherium* and *Dasypus*, have already been noticed as from the Brazilian caves. We have here, in addition, the huge *Mylodon* allied to the *Megatherium*, and the allied genera—*Grathopsis* and *Lestodon*. We then come to the huge extinct armadillos, *Glyptodon* and *Schistopleurum*, the former consisting of numerous species, some of which were as large as an elephant. Another genus, *Eutatus*, is allied to the living three-banded armadillos; and a species of the existing genus *Euphractus* has been found in Bolivia.

Toxodontidæ.—There remain a number of huge animals rivalling the Megatherium in size, and forming the genera *Toxodon* and *Nesodon*, but whose position is doubtful. Several species have been found in the deposits of the Pampas and Patagonia. They are allied at once to Ungulates, Rodents, Edentates, and the aquatic Sirenia, in so puzzling a manner that it is impossible to determine to what order they belong, or whether they require a new order to be formed for their reception. Some are believed to date back to the Miocene period, and they indicate what strange forms may still be discovered, should any

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productive deposits be found in South America of middle Tertiary age.

Pliocene Mammalia of the Antilles.—These may be noticed here, as they are of special interest, proving the connection of the larger West Indian Islands with the Continent some time in the later Tertiary period. They consist of remains of two large animals belonging to the South American Chinchillidæ, found in cave deposits in the island of Anguilla, and forming two new genera, *Amblyrhiza* and *Loxomylus*; and remain allied to *Megalonyx* from Cuba, which have been named *Megalocnus* and *Myomorphus*.

Eocene fauna of South America.—The few remains yet discovered in the Tertiary deposits of the Pampas which are believed to be of Eocene age, are exceedingly interesting, because they show us another change in the scenery of the great drama of life; there being apparently a considerable resemblance, at this epoch, between South America and Europe. They consist of a large extinct feline animal, *Eutemnodus*; of *Palæotherium* and *Anoplotherium*, the well-known extinct Ungulates of the European Tertiaries, and which have never been found in North America; and of three genera of Rodents,—*Theridomys*, allied to *Echimys*, and found also in the Eocene and Miocene of France; *Megamys*, allied to the living *Capromys* of the Antilles, and also to *Palæomys*, an extinct form of the French Miocene; and a very large animal referred to *Arvicola*, a genus found also in the Pliocene deposits of South America, and abundant in the northern hemisphere. No Edentates have been found.

The resemblances of this fauna to that of Europe rather than to any part of America, are so strong, that they can hardly be accidental. We greatly want, however, more information on this point, as well as some corresponding evidences as to the condition of West and South Africa about the same epoch, before we can venture to speculate on their bearing as regards the early migrations of organic forms.

General Remarks on the Extinct Mammalian Fauna of the Old

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and New Worlds.—Leaving the more special applications of palæontological evidence to be made after discussing the relations of the existing fauna of the several regions, we propose here to indicate briefly, some of the more general deductions from the evidence which has now been laid before our readers.

The first, and perhaps the most startling fact brought out by our systematic review, is the very recent and almost universal change that has taken place in the character of the fauna, over all the areas we have been considering; a change which seems to be altogether unprecedented in the past history of the same countries as revealed by the geological record. In Europe, in North America, and in South America, we have evidence that a very similar change occurred about the same time. In all three we find, in the most recent deposits—cave-earths, peat-bogs, and gravels—the remains of a whole series of large animals, which have since become wholly extinct or only survive in far-distant lands. In Europe, the great Irish elk, the *Machairodus* and cave-lion, the rhinoceros, hippopotamus, and elephant;—in North America, equally large felines, horses and tapirs larger than any now living, a llama as large as a camel, great mastodons and elephants, and abundance of huge megatheroid animals of almost equal size;—in South America these same megatheroids in greater variety, numerous huge armadillos, a mastodon, large horses and tapirs, large porcupines, two forms of antelope, numerous bears and felines, including a *Machairodus*, and a large monkey,—have all become extinct since the deposition of the most recent of the fossil-bearing strata. This is certainly not a great while ago, geologically; and it is *almost* certain that this great organic revolution, implying physical changes of such vast proportions that they must have been due to causes of adequate intensity and proportionate range, has taken place since man lived on the earth. This is proved to have been the case in Europe, and is supported by much evidence both as regards North and South America.

It is clear that so complete and sudden a change in the higher forms of life, does not represent the normal state of things. Species and genera have not, at all times, become so rapidly extinct. The time occupied by the "Recent period," that is the

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time *since* these changes took place is, geologically, minute. The time of the whole of the Post-Pliocene period, as measured by the amount of physical and *general* organic change known to have taken place, is exceedingly small when compared with the duration of the Pliocene period, and still smaller, probably, as compared with the Miocene. Yet during these two periods we meet with no such break in the continuity of the forms of life, no such radical change in the *character* of the fauna (though the number of specific and generic changes may be as great) as we find in passing from the Post-Pliocene to recent times. For example, in Central Europe numerous hyænas, rhinoceroses, and antelopes, with the great *Machairodus*, continued from Miocene all through Pliocene into Post-Pliocene times; while hippopotami and elephants continued to live through a good part of the Pliocene and Post-Pliocene periods,—and then all suddenly became extinct or left the country. In North America there has been more movement of the fauna in all the periods; but we have similar great felines, horses, mastodons, and elephants, in the Pliocene and Post-Pliocene periods, while *Rhinoceros* is common to the Miocene and Pliocene, and camels range continuously from Miocene, through Pliocene, to Post-Pliocene times;—when all alike became extinct. Even in South America the evidence is, as far as it goes, all the same way. We find *Machairodus*, *Equus*, *Mastodon*, *Megatherium*, *Scelidotherium*, *Megalonyx*, and numerous gigantic armadillos, alike in the caves and in the stratified tertiary deposits of the Pampas;—yet all have since passed away.

It is clear, therefore, that we are now in an altogether exceptional period of the earth's history. We live in a zoologically impoverished world, from which all the hugest, and fiercest, and strangest forms have recently disappeared; and it is, no doubt, a much better world for us now they have gone. Yet it is surely a marvellous fact, and one that has hardly been sufficiently dwelt upon, this sudden dying out of so many large mammalia, not in one place only but over half the land surface of the globe. We cannot but believe that there must have been some physical cause for this great change; and it must have been a cause capable of acting almost simultaneously over large

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portions of the earth's surface, and one which, as far as the Tertiary period at least is concerned, was of an exceptional character. Such a cause exists in the great and recent physical change known as "the Glacial epoch." We have proof in both Europe and North America, that just about the time these large animals were disappearing, all the northern parts of these continents were wrapped in a mantle of ice; and we have every reason to believe that the presence of this large quantity of ice (known to have been thousands of feet if not some miles in thickness) must have acted in various ways to have produced alterations of level of the ocean as well as vast local floods, which would have combined with the excessive cold to destroy animal life. There is great difference of opinion among geologists and physicists as to the extent, nature, and duration of the Glacial epoch. Some believe it to have prevailed alternately in the northern and southern hemispheres; others that it was simultaneous in both. Some think there was a succession of cold periods, each lasting many thousands of years, but with intercalated warm periods of equal duration; others deny that there is any evidence of such changes, and maintain that the Glacial epoch was one continuous period of arctic conditions in the temperate zones, with some fluctuations perhaps but with no regular alternations of warm periods. Some believe in a huge ice-cap covering the whole northern hemisphere from the pole to near 50° north latitude in the eastern, and 40° in the western hemisphere; while others impute the observed effects either to glaciers from local centres, or to floating icebergs of vast size passing over the surface during a period of submersion.

Without venturing to decide which of these various theories will be ultimately proved to be correct, we may state, that there is an increasing belief among geologists in the long duration of this ice-period, and the vast extent and great thickness attained by the ice-sheet. One of the most recent, and not the least able, of the writers on this question (Mr. Belt) shows strong reasons for adopting the view that the ice-period was simultaneous in both hemispheres; and he calculates that the vast amount of water abstracted from the ocean and locked up

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in mountains of ice around the two poles, would lower the general level of the ocean about 2,000 feet. This would be equivalent to a general elevation of the land to the same amount, and would thus tend to intensify the cold; and this elevation may enable us to understand the recent discoveries of signs of glacial action at moderate elevations in Central America and Brazil, far within the tropics. At the same time, the weight of ice piled up in the north would cause the land surface to sink there, perhaps unequally, according to the varying nature of the interior crust of the earth; and since the weight has been removed land would rise again, still somewhat irregularly; and thus the phenomena of raised beds of arctic shells in temperate latitudes, are explained.

Now, it is evident, that the phenomena we have been considering—of the recent changes of the mammalian fauna in Europe, North America, South Temperate America, and the highlands of Brazil—are such as might be explained by the most extreme views as to the extent and vastness of the ice-sheet, and especially as to its simultaneous occurrence in the northern and southern hemispheres; and where two such completely independent sets of facts are found to combine harmoniously, and supplement each other on a particular hypothesis, the evidence in favour of that hypothesis is greatly strengthened. An objection that will occur to zoologists, may here be noticed. If the Glacial epoch extended over so much of the temperate and even parts of the tropical zone, and led to the extinction of so many forms of life even within the tropics, how is it that so much of the purely tropical fauna of South America has maintained itself, and that there are still such a vast number of forms, both of mammalia, birds, reptiles, and insects, that seem organized for an exclusive existence in tropical forests? Now Mr. Belt's theory, of the subsidence of the ocean to the extent of about 2,000 feet, supplies an answer to this objection; for we should thus have a tract of lowland of an average width of some hundreds of miles, added to the whole east coast of Central and South America. This tract would, no doubt, become covered with forests as it was slowly formed, would enjoy a perfectly

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tropical climate, and would thus afford an ample area for the continued existence and development of the typical South American fauna; even had glaciers descended in places so low as what is now the level of the sea, which, however, there is no reason to believe they ever did. It is probable too, that this low tract, which all round the Gulf of Mexico would be of considerable width, offered that passage for intermigration between North and South America, which led to the sudden appearance in the former country in Post-Pliocene times, of the huge Megatheroids from the latter; a migration which took place in opposite directions as we shall presently show.

The birth-place and migrations of some mammalian families and genera.—We have now to consider a few of those cases in which the evidence already at our command, is sufficiently definite and complete, to enable us to pronounce with some confidence as to the last movements of several important groups of mammalia.

Primates.—The occurrence in North America of numerous forms of Lemuroidea, forming two extinct families, which are believed by American palæontologists to present generalized features of both Lemuridæ and Hapalidæ, while in Europe only Lemurine forms allied to those of Africa have occurred in deposits of the same age (Eocene), renders it possible that the Primates may have originated in America, and sent one branch to South America to form the Hapalidæ and Cebidæ, and another to the Old World, giving rise to the lemurs and true apes. But the fact that apes of a high degree of organization occur in the European Miocene, while in the Eocene, a monkey believed to have relations to the Lemuroids and Cebidæ has also been discovered, make it more probable that the ancestral forms of this order originated in the Old World at a still earlier period. The absence of any early tertiary remains from the tropical parts of the two hemispheres, renders it impossible to arrive at any definite conclusions as to the origin of groups which were, no doubt, always best developed in tropical regions.

Carnivora.—This is a very ancient and wide-spread group, the families and genera of which had an extensive range in very

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early times. The true bears (*Ursus*) are almost the only important genus that seems to have recently migrated. In Europe it dates back to the Older Pliocene, while in North America it is Post-Pliocene only. Bears, therefore, seem to have passed into America from the Palæarctic region in the latter part of the Pliocene period. They probably came in on the north-west, and passed down the Andes into South America, where one isolated species still exists.

Ungulata.—Horses are very interesting. In Europe they date back under various forms to the Miocene period, and true *Equus* to the Older Pliocene. In North America they are chiefly Pliocene, true *Equus* being Post-Pliocene, with perhaps one or two species Newer Pliocene; but numerous ancestral forms date back to the Miocene and Eocene, giving a more perfect "pedigree of the horse" than the European forms, and going back to a more primitive type—*Orohippus*. In South America, *Equus* is the only genus, and is Post-Pliocene or at most Newer Pliocene. While, therefore, the ancient progenitors of the Equidæ were common to North America and Europe, in Miocene and even Eocene times, true horses appear to have arisen in the Palæarctic region, to have passed into North America in the latter part of the Pliocene period, and thence to have spread over all suitable districts in South America. They were not, however, able to maintain themselves permanently in their new territory, and all became extinct; while in their birth-place, the Old World, they continue to exist under several varied forms.

True tapirs are an Old World group. They go back to the Lower Miocene in Europe, while in both North and South America they are exclusively Post-Pliocene. They occur in France down to the Newer Pliocene, and must, about that time, have entered America. The land connection by which this and so many other animals passed between the Old and New Worlds in late Tertiary times, was almost certainly in the North Pacific, south of Behring's Straits, where, as will be seen by our general map, there is a large expanse of shallow water, which a moderate elevation would convert into dry land, in a sufficiently temperate latitude.

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The peccary (*Dicotyles*), now a characteristic South American genus, is a recent immigrant from North America, where it appears to have been developed from ancestral forms of swine dating back to the Miocene period.

Antelopes are an Old World type, but a few of them appear to have entered North, and reached South America in late Pliocene times. Camels, strange to say, are a special North American type, since they abounded in that continent under various ancient forms in the Miocene period. Towards the end of that period they appear to have entered eastern Asia, and developed into the Siberian *Merycotherium* and the North Indian *Camelus*, while in the Pliocene age the ancestral llamas entered South America.

Cervidæ are a wide-spread northern type in their generalized form, but true deer (*Cervus*) are Palæarctic. They abounded in Europe in Miocene times, but only appear in North and South America in the later Pliocene and Post-Pliocene periods.

True oxen (*Bovinæ*) seem to be an Oriental type (Miocene), while they appear in Europe only late in the Pliocene period, and in America are confined to the Post-Pliocene.

Elephants (*Elephantidæ*) are an Old World type, abounding in the Miocene period in Europe and India, and first appearing in America in Post-Pliocene or later Pliocene times. Ancestral forms, doubtfully Proboscidean (*Dinocerata*), existed in North America in the Eocene period, but these became extinct without leaving any direct descendants, unless the *Brontotheridæ* and rhinoceroses may be so considered.

Marsupials are almost certainly a recent introduction into South and North America from Asia. They existed in Europe in Eocene and Miocene times, and presumably over a considerable part of the Old World; but no trace of them appears in North or South America before the Post-Pliocene period.

Edentata.—These offer a most curious and difficult problem. In South America they abound, and were so much more numerous and varied in the Post-Pliocene and Pliocene, that we may be sure they lived also in the preceding Miocene period. A few living Edentates are scattered over Africa and Asia, and

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they flourished in Europe during the Miocene age—animals as large (in some species) as a rhinoceros, and most allied to living African forms. In North America no trace of Edentata has been found earlier than the Post-Pliocene period, or perhaps the Newer Pliocene on the west coast. Neither is there any trace of them in South America in the Eocene formations; but this may well be owing to our very imperfect knowledge of the forms of that epoch. Their absence from North America is, however, probably real; and we have to account for their presence in the Old World and in South America. Their antiquity is no doubt very great, and the point of divergence of the Old World and South American groups, may take us back to early Eocene, or even to Pre-Eocene times. The distribution of land and sea may then have been very different from what it is now; and to those who would create a continent to account for the migrations of a beetle, nothing would seem more probable than that a South Atlantic continent, then united parts of what are now Africa and South America. There is, however, so much evidence for the general permanence of what are now the great continents and deep oceans, that Professor Huxley's supposition of a considerable extension of land round the borders of the North Pacific Ocean in Mesozoic times, best indicates the probable area in which the Edentate type originated, and thence spread over much of the Old World and South America. But while in the latter country it flourished and increased with little check, in the other great continents it was soon overcome by the competition of higher forms, only leaving a few small-sized representatives in Africa and Asia.

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